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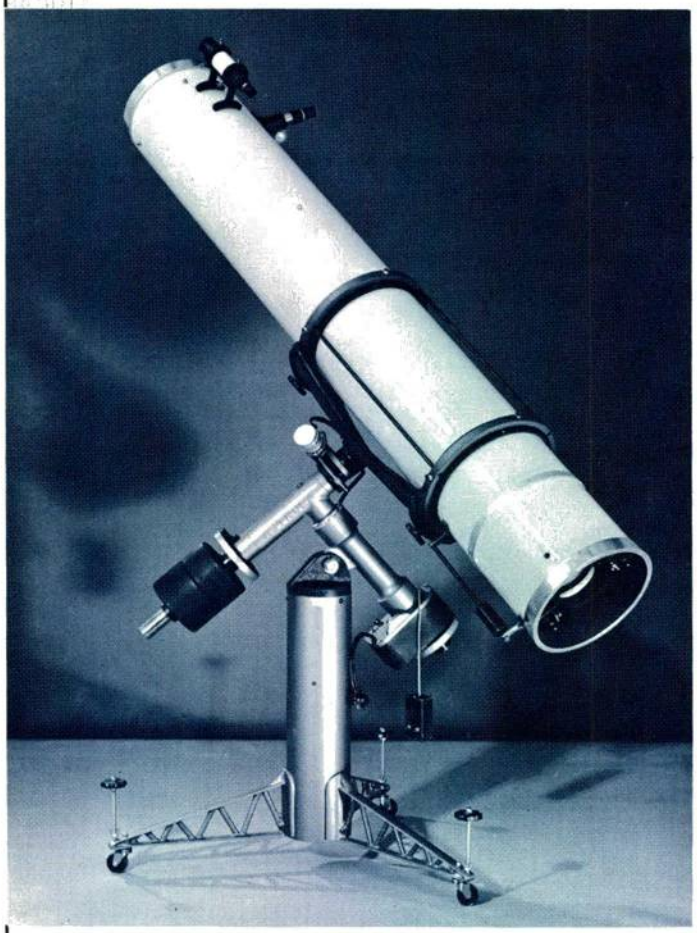

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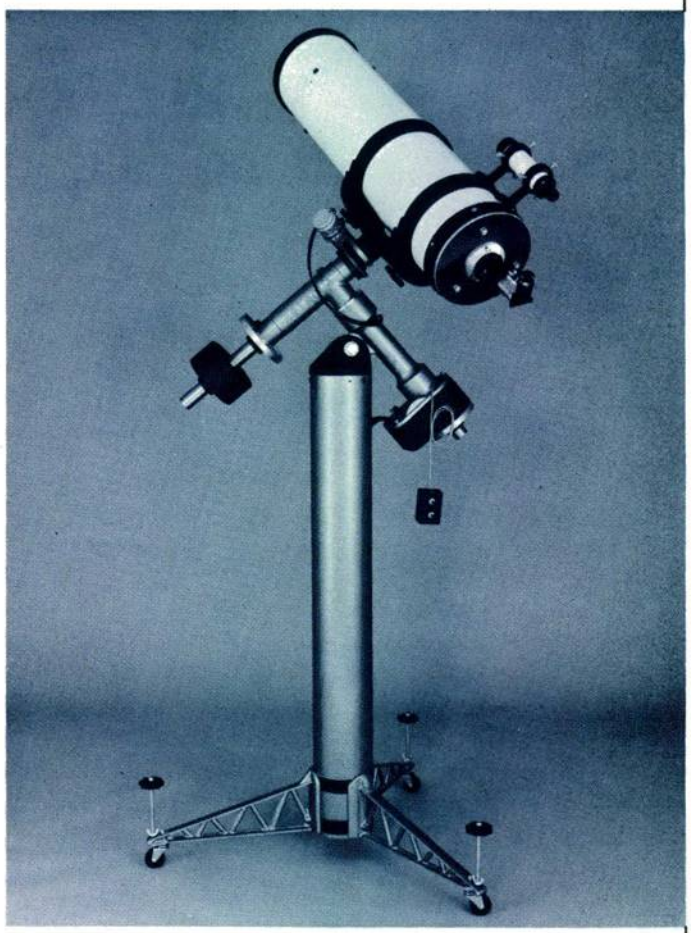

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COVER

Photograph by Orien A. Ernest

Like a plume of pale blue smoke the western portion of the Veil nebula threads its way among the distant stars. This remnant of an exploded star is about 10 light-years long but is so diffuse that future spacecraft could plunge through it with less difficulty than an airliner penetrates a puffy cloud. The Veil's visibility is somewhat a mystery — it seems to be illuminated by a hot star but no specific star is known to be responsible. This photograph — among the finest ever obtained in color — is a one hour exposure on High Speed Ektachrome (cooled emulsion camera) through a 16 inch Newtonian reflector. Ernest's photo of the entire area around the Veil is part of this month's review of Cygnus in Constellation Close-Up, page 60.

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Planet of the Double Sun

by
Isaac Asimov

The title sounds as though this were going to be a rather old fashioned science fiction story, doesn't it? Yet although the title may sound old fashioned, the situation need not be. One of the most glamorous settings that can be imagined is that of more than one sun in the sky.

The author of a story describing such a setting need not (and usually does not) worry about the astronomic verities of the situation. The suns are usually described as looking like suns and both (or all) are made to move independently in the sky. The author will usually throw in local color by saying that one sun was just rising, while the other had just passed zenith. He may make matters more colorful (figuratively and literally) by having one sun, for example, red and the other blue. Then he can talk of double shadows

The brilliant golden ball hovering just above the horizon is the main star of the Alpha Centauri system. It could be mistaken for our sun if we were transported to this hypothetical Earthlike planet. Something definitely not Earthlike is the brilliant orange star, the second member of this stellar duo which shines 400,000 times brighter than the planet Venus. This smaller sun, 20 times farther away, is clearly visible in daylight from this world making it a "planet of the double sun". A satellite similar to our moon completes the scene.

Artwork by Victor Costanzo

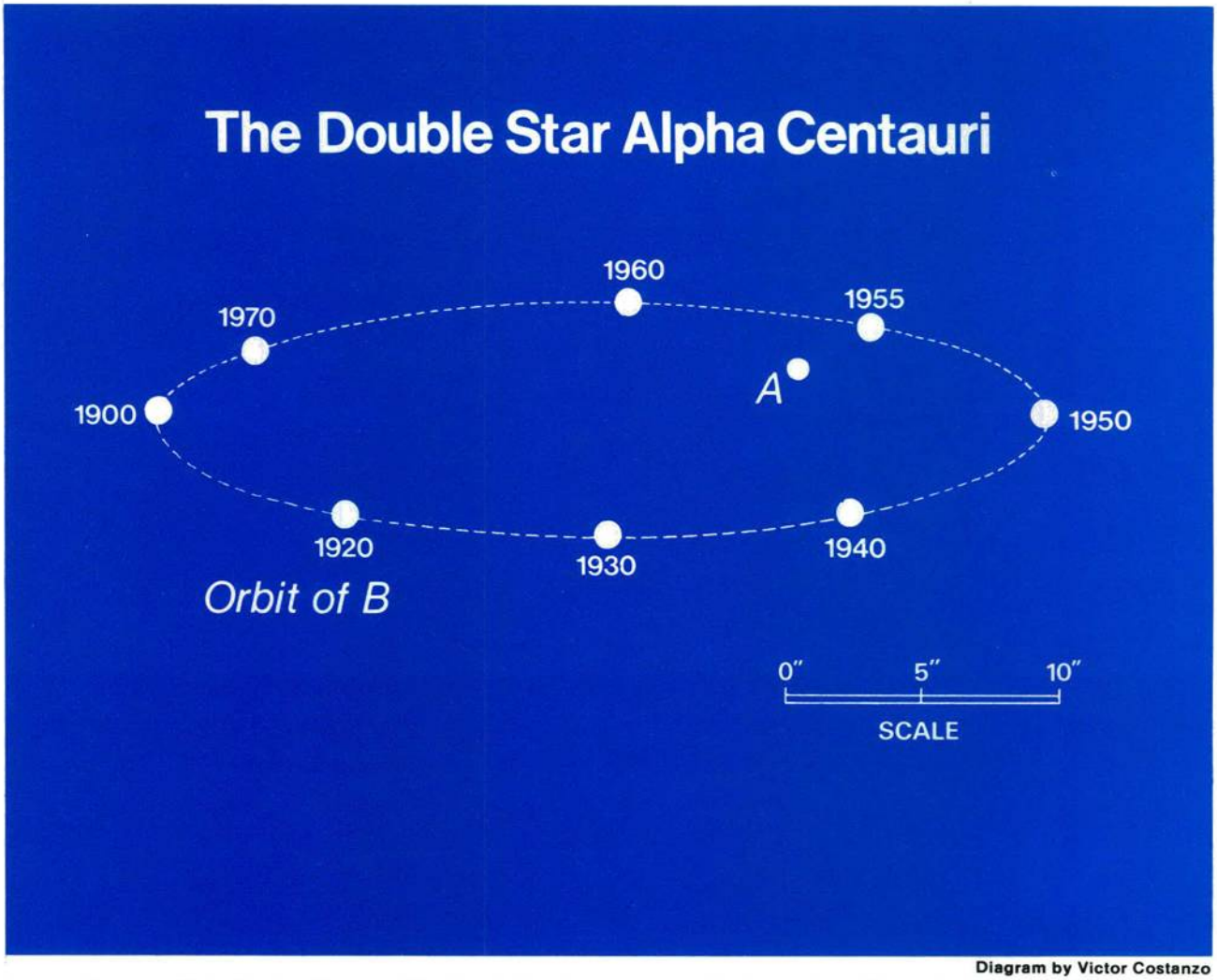


Diagram by Victor Costanzo

In a small scope, Alpha Centauri is one of the finest double stars in the sky. The components orbit each other once every 80 years and are now near maximum separation of 22 seconds of arc. (For comparison, Albireo — the best known double star — has a 34 second separation.) The dates represent observed positions of component B. Actually the two stars have more nearly circular motions than seen here, but from Earth we see the orbits almost edge-on. Unfortunately Alpha Centauri can't be seen north of 30 degrees north latitude.

and their various configurations and color combinations.

A little of this is enough to make us sigh at our misfortune in having only one sun in the sky — and a pretty colorless one at that. Oh, the missing glories!

What would it be like to have more than one sun in the sky? There are, of course, a wide variety of types of multiple stars; some are made up of two components and some of more than two. In some multiple stars, the components are near together; in others, far apart. The components may be similar or dissimilar; one may be a red giant or one may be a white dwarf.

But let's not make up any systems or look for something exotic or foreign. The fact of the matter is that we have an example in our backyard. The nearest star to us in space — a star so close we can almost reach out and touch it, a next-door neighbor no more than 25 trillion miles away, good old Alpha Centauri — is a multiple star.

Suppose we were on a planet in the Alpha Centauri system. What would it be like? To begin with, what is Alpha Centauri like?

Alpha Centauri is a star in the southern celestial hemisphere. It is never visible in the sky north of about 30 degrees north latitude. The chances are you've never seen it. Moreover, the ancient Greeks never saw it.

The chief observatories of the medieval Arabs in Cordova, Bagdad and Damascus were all north of the 30 degree line. Presumably ordinary Arabs in the Arabian and Sahara deserts must occasionally have seen a bright star very near the southern horizon, but this apparently did not penetrate to the egghead level. The test of the matter is that Alpha Centauri, although the

third brightest star in the sky, has no name of its own — neither Greek nor Arabic. (The name Alpha Centauri is official "astronomese".)

Of course, once Europeans started adventuring down the coast of Africa in the late 1400s, the bright star must have been observed at once. Eventually astronomers got around to making star maps of those parts of the southern celestial hemisphere invisible from Europe. They named the constellations in Latin, naturally, and included mythological creatures as a further match to what already existed in the sky, just as planets discovered in modern times received mythological names matching the older ones. One of the prominent southern constellations was named the Centaur. In Latin, this is Centaurus — and the genitive ("of the Centaur") is Centauri.

Centaurus contains two first magnitude stars. The brighter was named Alpha Centauri and the other, Beta Centauri. The words "alpha" and "beta" are not only the first two letters of the Greek alphabet, but were also used by the Greeks to represent the numbers "one" and "two", a habit never broken by scientists. The names of the stars freely translated therefore mean "star number one of the Centaur" and "star number two of the Centaur", respectively.

The magnitude of Alpha Centauri is -0.3 which makes it, as said, the third brightest star of the sky. The only stars brighter are Canopus (-0.7) and, of course, Sirius (-1.4).

(The lower the magnitude, the brighter the star, in a logarithmic ratio. A difference in magnitude of one unit means a difference in brightness of 2.512 times. A difference in magnitude of two units means a difference in brightness of 2.512 x 2.512 or about 6.31 times, and so on.)

Around 1650, telescopes became good enough to detect the fact that some stars, which looked like single points of light to the naked eye, were actually two closely spaced points of light. In 1685 Jesuit missionaries in Africa, taking time out for astronomical observations, first noticed that Alpha Centauri is an example of such a double star. The brighter component is Alpha Centauri A; the other, Alpha Centauri B.

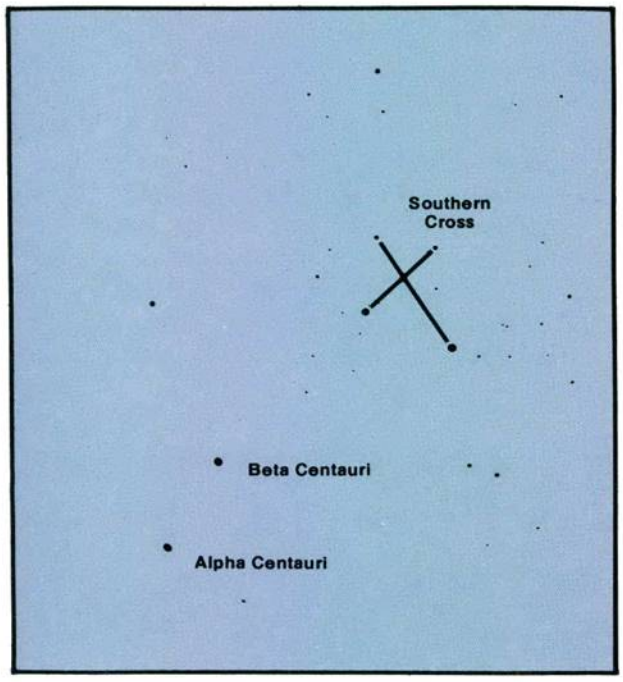
The magnitude of Alpha Centauri A by itself is 0.0 and that of Alpha Centauri B is +1.4. The 1.4 difference in magnitude means that Alpha Centauri A is 3.6 times as bright as Alpha Centauri B. To translate the brightness into absolute terms — that is, to compare either component with our sun — it is necessary to know the distance of Alpha Centauri.

This distance can be measured by noting slight shifts in the star's position, mirroring the change in Earth's position as it revolves about the sun. This tiny yearly motion of a star, resulting from Earth's motion, is called stellar parallax and grows smaller as the distance of a star increases. A very distant star has virtually no parallax at all, so it can be treated as a motionless reference point against which the parallax of a nearby star could be measured. (Without some reference point, parallax is meaningless.)

THE 10 NEAREST STARS

Name	Distance (light-years)	Mag.	Type	Luminosity (sun = 1)
Alpha Centauri A	4.3	0.0	solar	1.3
Alpha Centauri B	4.3	+1.4	solar	0.36
Alpha Centauri C	4.3	+11.0	red dwarf	0.00006
Barnard's Star	5.9	+9.5	red dwarf	0.00044
Wolf 359	7.6	+13.5	red dwarf	0.00002
Lal. 21185	8.1	+7.5	red dwarf	0.0052
Sirius A	8.6	-1.4	solar	23.0
Sirius B	8.6	+7.2	white dwarf	0.008
UV Ceti A	8.9	+12.5	red dwarf	0.0006
UV Ceti B	8.9	+13.0	red dwarf	0.0004

Photograph by John Pazmino



Never seen from all but the southern extremes of the United States, Alpha Centauri is amidst a brilliant group of constellations. (The key to the central area of the photo is contained in the chart.) Beta Centauri, magnitude + 0.6, has no relationship to Alpha other than name. A line from Alpha through Beta leads to the Southern Cross, properly known as the constellation Crux. The photo was taken from Colombia, South America.

No star has been found closer than those of the Alpha Centauri system which lie at a distance of 4.3 light-years, or 25 trillion miles.

Knowing the distance of Alpha Centauri, it is easy to calculate that Alpha Centauri A (the brighter of the pair) is almost exactly as bright as our sun. Since its spectrum shows it to be at the same surface temperature, it is our sun's twin — same diameter, same mass, same brightness, same everything apparently.

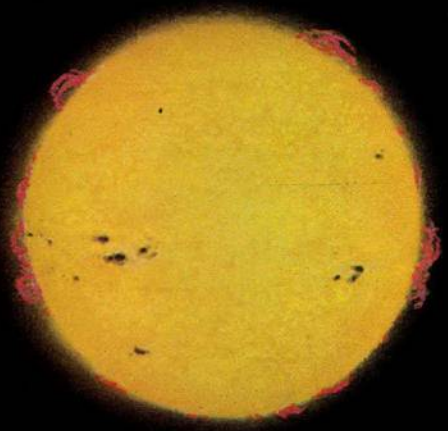
As for Alpha Centauri B, it is slightly larger than A but much cooler so it appears to be fainter because it is giving off less light per unit area. The two stars rotate in elliptical orbits about a common center of gravity. The period of rotation is about 80 years. When the stars are closest, they are about a billion miles apart. At their farthest, they are 3.3 billion miles apart.

Now suppose we try to duplicate (in imagination) the Alpha Centauri system here in our own solar system. Since Alpha Centauri A is the twin of our sun in every respect, let's suppose our sun is Alpha Centauri A — but let's keep on referring to it, for convenience's sake, as the sun.

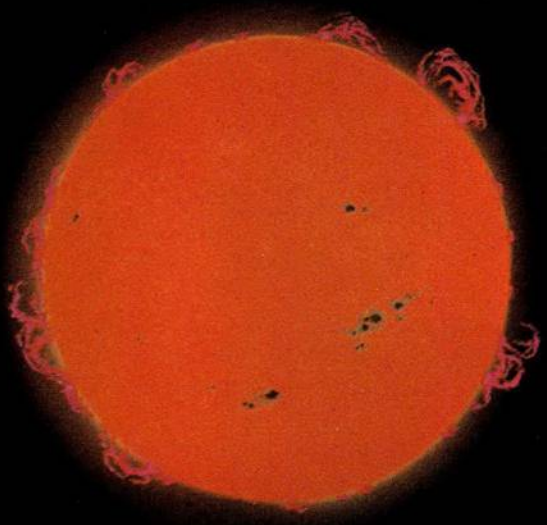
Let's imagine Alpha Centauri B (which we will call simply sun B) in orbit about the sun. Furthermore, let's suppose sun B is traveling in a nearly circular orbit, in generally the same plane as the planets, and at the average distance of Alpha Centauri B from Alpha Centauri A (a change in detail but not in essence). This would place it in orbit about two billion miles from the sun. This is almost as though we have taken the planet Uranus of our solar system and replaced it with Alpha Centauri B.

All this would make Earth part of a multiple star system very closely resembling that of Alpha Centauri. Now what would the heavens be like?

Alpha Centauri System



ALPHA CENTAURI A is almost identical to our sun in every respect. Its diameter is about 925,000 miles, compared to 864,000 for the sun, and it is slightly (about 10 percent) more massive. Both the sun and Alpha Centauri A are spectral class G2 and have 11,000 degree surface temperatures. Sunspots, prominences and the rest of the activity we see on the sun are likely also present on this star. Total light output from Alpha Centauri A is about 35 percent greater than the sun's. Earth would have to be in orbit about six million miles farther out from A to encounter conditions equivalent to those of our solar system.



ALPHA CENTAURI B has 75 percent of A's mass but only 25 percent of its brilliance. This is due to B's lower temperature (spectral class K1) even though its diameter is about 1,050,000 miles. Prominences surging from the surface of this star are probably larger than the sun's due to lower gravity caused by B's smaller mass and fairly large size. Alpha Centauri A and B orbit one another once in 80 years in elliptical paths. The minimum distance between them is about one billion miles while the maximum is nearly 3.3 billion miles — about the distance from the sun to Pluto.

ALPHA CENTAURI C is often called Proxima Centauri because it is believed to be slightly nearer than the two main stars of the system. Discovered in 1915, this tiny star is only 50,000 miles across and one trillion miles from the main suns. This tremendous distance (300 times the distance from Earth to Pluto) combined with Proxima's feeble light output would make it no brighter than a fifth magnitude star when viewed from a planet of A. Proxima's huge orbit is poorly known but it is thought that the star takes about 500,000 years for a single circuit. This small red dwarf star has been observed to double its brightness in only a few minutes. These surges in luminosity are probably due to eruptive flares like those of the sun — but they are comparative monsters on this small star.

Artwork by Victor Costanzo

In some ways, our solar system would be changed. Uranus, Neptune and Pluto, as we know them,would be out. Their orbits would be tangled with sun B. However these planets were unknown in the pretelescopic era, so we can do without them as far as naked eye observation is concerned.

And Saturn, the outermost of the planets known to the ancients, would probably have an unstable orbit — so we will exclude it too. But the sun should hang on to Jupiter and the closer planets with no trouble.

Sun B would behave like a new and very large "planet" of the sun. The sun and sun B would revolve about a center of gravity which would be located somewhere beyond Jupiter's orbit. The motion of the sun about this point once every 80 years would, however, not be detectable in pretelescopic days, because the sun would carry all the planets — including Earth — with it. Neither the sun's distance nor sun B's distance from Earth would be affected by that motion. (After the invention of the telescope, the sun's swing — with us in tow — would become noticeable through its reflection in the parallactic displacement of the nearer stars.)

But what would sun B look like in our heavens?

Well, it would not look like a sun. It would be a point of light like the other planets. A diameter of a million miles at a distance of two billion miles would subtend an angle of about 1-1/2 minutes of arc. Sun B would appear to the naked eye to be only twice the apparent size of the smaller but closer Jupiter.

To a naked eye observer (such as the Greeks or Babylonians), sun B would be one more point of light moving slowly against the stars. It would be moving more slowly than the others, making a complete circuit of the sky in about 80 years (as compared with 12 for Jupiter). From this, the Greeks would — rightly — conclude that sun B was farther from Earth than was any other planet.

Of course, one thing would make sun B very unusual and quite different from the other planets. It would be very bright. It would have an apparent magnitude of about -18. It would be only 1/3,000 as bright as the sun, to be sure, but it would still be 150 times as bright as the full moon. With sun B in the night sky, Earth would be well illuminated.

Another thing might be unusual about sun B — not as a matter of inevitability as with its brilliance, but as a matter of reasonable probability at least. As a "planet" of the solar system, why should it not have satellites as the other planets have? (Of course, its satellites would be revolving about a sun and would really be planets. But let's not worry about having consistent terminology.)

Since sun B is much larger than the other planets, it could be expected to have a satellite much larger and more distant from itself than is true for any other planet. It might, for instance, have a satellite the size of Uranus. (Why not? Uranus would be much smaller compared to sun B, than Jupiter is compared to the sun. If the sun can have Jupiter in tow, then it's perfectly reasonable to allow sun B to have a planet the size of Uranus.)

Uranus could be circling sun B at a distance of 100 million miles. (Again, why not? Jupiter, which is considerably smaller than sun B and considerably closer to the competing gravity of the sun nevertheless manages to hold on to satellites at a distance of 15 million miles from itself. If Jupiter can manage that, sun B can manage 100 million.)

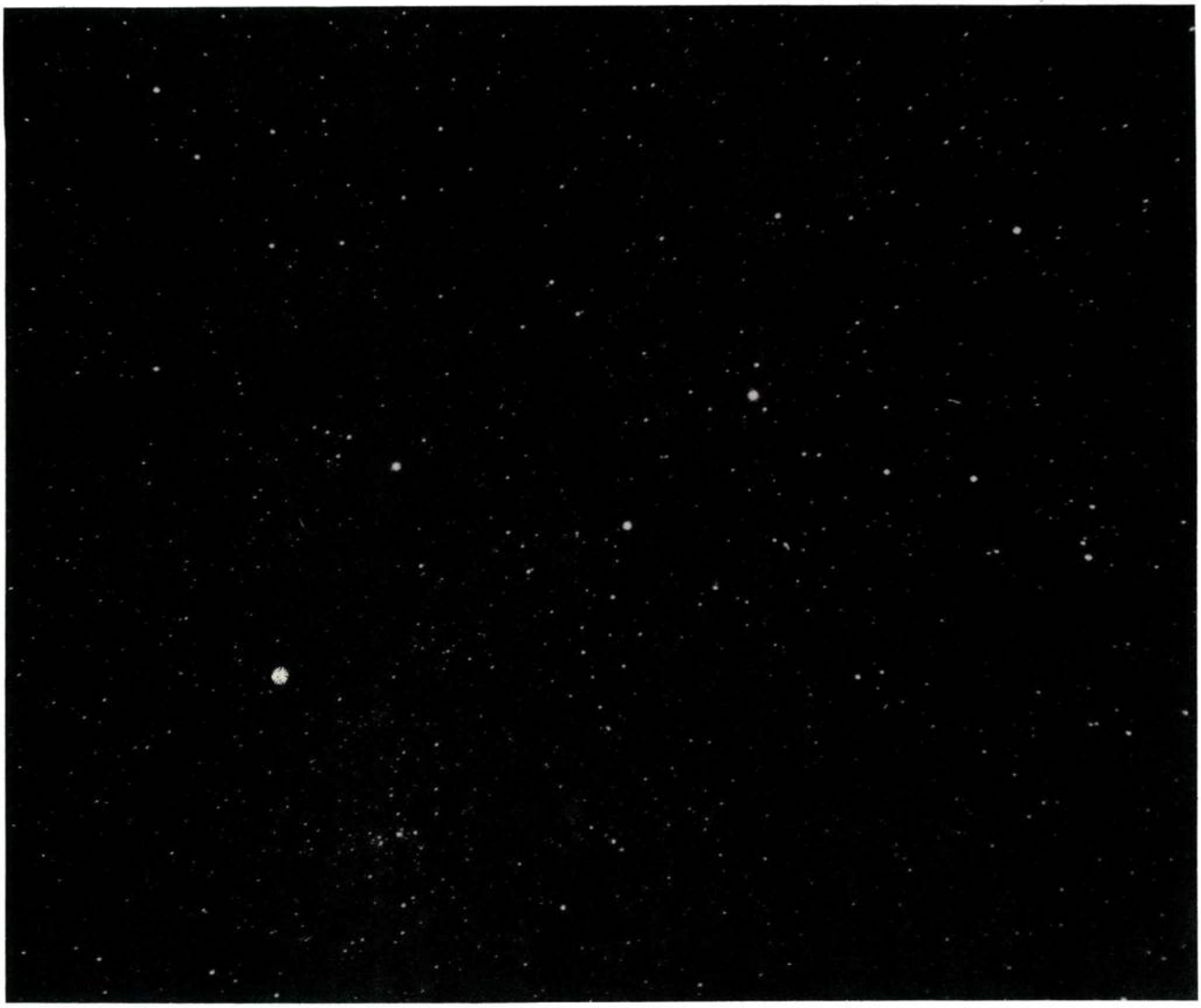
If Uranus moved about sun B in the plane of Earth's orbit, it would move first to one side of sun B, then back and to the other side, then back and to the first side, and so on, indefinitely. Its maximum separation from sun B would be about three degrees of arc. This is about six times the apparent diameter of the sun or moon and such a separation could easily be seen with the naked eye.

But would Uranus itself be visible at that distance from us?

Well right at the moment, without sun B, Uranus is visible. It is 1.8 billion miles from the sun (nearly as far as I have, in imagination, put sun B), and it has a magnitude of +5.7 which makes it just visible as a very faint star. But if Uranus were rotating about sun B, it would be lit up not merely by the dim light of the distant sun (the reflection of which is all we see Uranus by, actually) but also by the stronger rays of the much nearer sun B.

The average magnitude of Uranus under these conditions would be +1.7. It wouldn't be as bright as the other planets, but it would be brighter than the North Star, for instance. The glare of the nearby sun B might make Uranus harder to observe than the North Star, but it should still be clearly visible. (Sun B might have more than one satellite too, but let's not complicate the picture. One satellite will do.)

The Greeks would thus be treated to the spectacle not only of an unusually and exceptionally brilliant point of light but also to another much dimmer point of light that oscillated back and



From Alpha Centauri the constellation Cassiopeia would be altered by the addition of our sun. Appearing as a first magnitude star, the sun would add an extra arm to Cassiopeia's "W" shape.

forth as though caught in the grip of the brighter point. Both factors — brilliance and a visible satellite — would be completely unique. I have a theory that this would have made an interesting difference in Greek thinking, both on the mythological and the scientific level.

First mythology, since Greek mythology is older than Greek science and that involves the "synodic period" of a planet. This is the interval between successive meetings of a planet and the sun in our sky. Jupiter and the sun meet every 399 days; Saturn and the sun every 378 days. Sun B and the sun would meet in Earth's sky every 369 days. This is just a measure of how frequently Earth in its revolution manages to get on the other side of the sun from the planet in question.

As the planet approaches the sun it spends less and less time in the night sky and more and more time in the day sky. For ordinary planets this means it becomes less visible to the naked eye because it is lost in the sun's glare during the day. Even the moon looks washed out by day.

But sun B would be different. Considering that it is 150 times as bright as the full moon, it would be a clearly visible point of light even by day. Allowing the use of smoked glasses, it could be followed right up to the sun.

Now the Greeks had a myth about how mankind learned of the use of fire. At the time of creation, man was naked, shivering, and miserable — one of the weakest and most poorly endowed of the animal creation. The demigod Prometheus had pity on the new creature and stole fire from the sun to give to mankind. With fire, man conquered night and winter and maraud-

ing beasts. He learned to smelt metals and developed civilization. But the anger of Zeus was kindled at this interference. Prometheus was taken to the very ends of the world (which, to the Greeks, were the Caucasus mountains) and chained to a rock. A vulture was sent there daily to tear at his liver, but it left him at night so that his liver might miraculously grow back and be ready for the next day's torture.

There now. Doesn't all this fit in perfectly with the apparent behavior of Sun B? Every year sun B commits the crime of Prometheus. It can be seen in the daytime approaching the sun — the only planet that can be seen to do this. It can only be planning to steal light from the sun, and it obviously succeeds. After all, isn't that why it is so much brighter than all the other planets, and why it is so much brighter than even the moon? Moreover, it brings this light to mankind, for when it is in the night sky, it illuminates the landscape into a dim kind of day.

But the planet is punished. It is cast out to the edge of the universe, farther away than any other planet. There is even a vulture tearing at it in the shape of its clearly visible satellite. While the planet was busy stealing fire from the sun, no satellite was visible (because it was drowned out by the sun's glare, of course). Once the planet was hurled to the edge of the universe, though, and became visible in the night sky, its satellite appeared. The satellite swoops toward the bright planet, tearing at it; then it moves away to allow it to recover, swoops in again, and so on in an eternal rhythm.

With all this in mind, isn't it just about inevitable that if sun B were in our sky, it would be named Prometheus? Or that the satellite would now have the Latin name Vulturius?

Could it be that such a heavenly situation actually existed and suggested the myth in the first place? Could it be that the human race originated on a planet circling Alpha Centauri A? Could they have migrated to Earth about 50,000 years ago, wiped out the primitive Neanderthals they found here and established a race of "true men"? Could some disaster have destroyed their culture and forced them to build up a new one?

Is the Prometheus myth a dim memory of the distant past, when Alpha Centauri B lit up the skies? Was the Alpha Centauri system the original of the Atlantis myth?

No, I don't think so. But anyone who wants to use it in a science fiction story is welcome to it. And anyone who wants to start a religious cult based on this notion probably can't be stopped, but please — don't say you read it here first.

And what effect would sun B (or "Prometheus") have had on Greek science? Well, in the real world, there was a time when matters hung in the balance. The popular Greek theory of the universe, as developed by 300 B.C., put Earth at the center and let everything in the heavens revolve about it. The weight of Aristotle's philosophy was on the side of this theory.

About 280 B.C., Aristarchus of Samos suggested that only the moon revolved about Earth. The planets — including Earth itself — he said, revolved about the sun, thus elaborating a heliocentric system. He even had some good notions concerning the relative sizes and distances of the moon and sun.

For a while, the Aristarchean view seemed to have an outside chance despite the great prestige of Aristotle. However, about 150 B.C., Hipparchus of Nicaea worked out the mathematics of the geocentric system so thoroughly that the competition ended. About 150 A.D. Claudius Ptolemy put the final touches on the geocentric theory and no one questioned that Earth was the center of the universe for nearly 1,400 years thereafter.

But had Prometheus and Vulturius been in the sky, the Greeks would have had an example of one heavenly body, anyway, that clearly did not revolve primarily about Earth. Vulturius would have revolved about Prometheus. Aristarchus would undoubtedly have suggested Prometheus to be another sun with a planet circling it. The argument by analogy would, it seems to me, certainly have won out. Copernicus would have been anticipated.

Furthermore, the motions of Vulturius about Prometheus would have given a clear indication of the workings of gravity. The Aristotelian notion that gravity was confined to Earth alone and that heavenly bodies were immune to it would not have stood up. Undoubtedly Newton too would have been anticipated by some 2,000 years.

What would have happened next? Would Greek genius have decayed anyway? Would the Dark Ages still have intervened? Or would the world have had a 2,000 year headstart in science — and would we now be masters of space? Or would we possibly be the nonsurvivors of a nuclear war fought in Roman times?

So that's how it goes. You start off checking on colored shadows in a science fiction story and end up wondering how different human history might have been (either for good or evil) if only the sun had had a companion star in its lonely voyage through eternity.

Dr. Isaac Asimov is the world's best known and most prolific science writer. One of the latest of his nearly 160 books is **Asimov on Astronomy,** *published by Doubleday & Co., Inc. (1974). This article is a chapter from that book which was revised especially for use in ASTRONOMY.*

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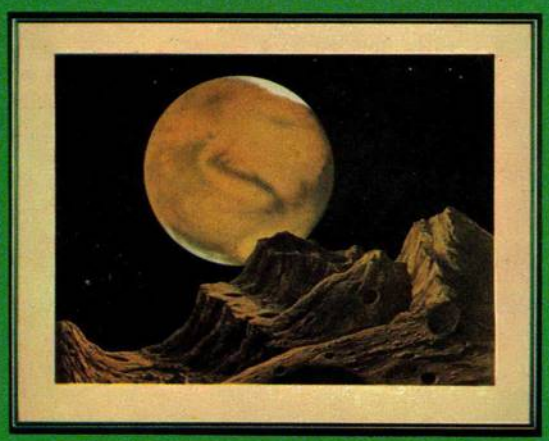

Mars as Seen From Deimos

The artistic imagination of Victor Costanzo is boldly displayed in this 17 x 22 inch full color lithograph of the red planet Mars as it would appear from its outer satellite Deimos. Costanzo's painstaking accuracy in this rendition is given further credence because he incorporated real constellations in the sky background. To the lower left of the planet is the Hyades star cluster in Taurus, and to the upper right is the constellation Aries. This artwork was first used as a two page spread in ASTRONOMY's May issue to illustrate "The Lost Pictures of Mars" by Carl Sagan. It is available framed as above or unframed.

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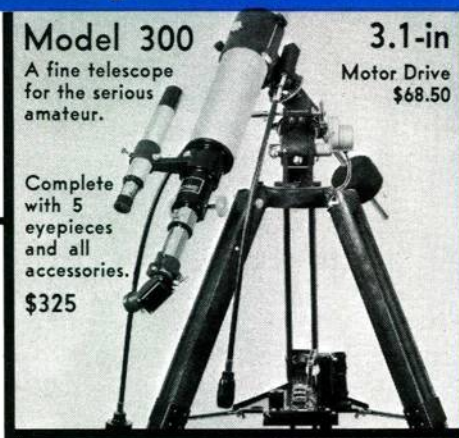

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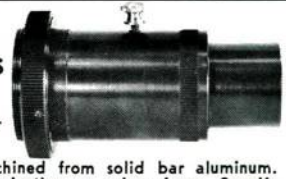

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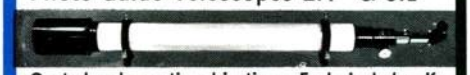

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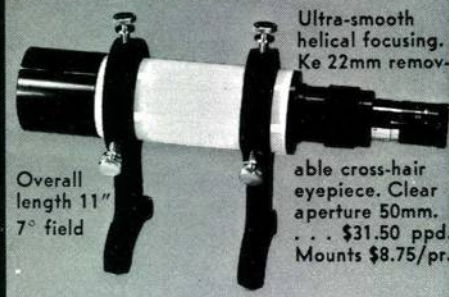

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ASTRO-NEWS

Latest News From the World of Astronomy

Three Visits to Mercury

It seems likely that Mariner 10 will be making a second encounter with Mercury on Sept. 21, 1974 and a third visit to the planet in late March, 1975. So far, all trajectory correction maneuvers have gone successfully; the vehicle is on target to pass 29,400 miles above the southern hemisphere of Mercury on Sept. 21.

Experimenters involved in the magnetic field and atmospheric studies of Mercury had urged a pass by the night side of the planet. This would yield confirming information on the atmospheric content and nature of the unsuspected but apparently existing magnetic field around the smallest planet.

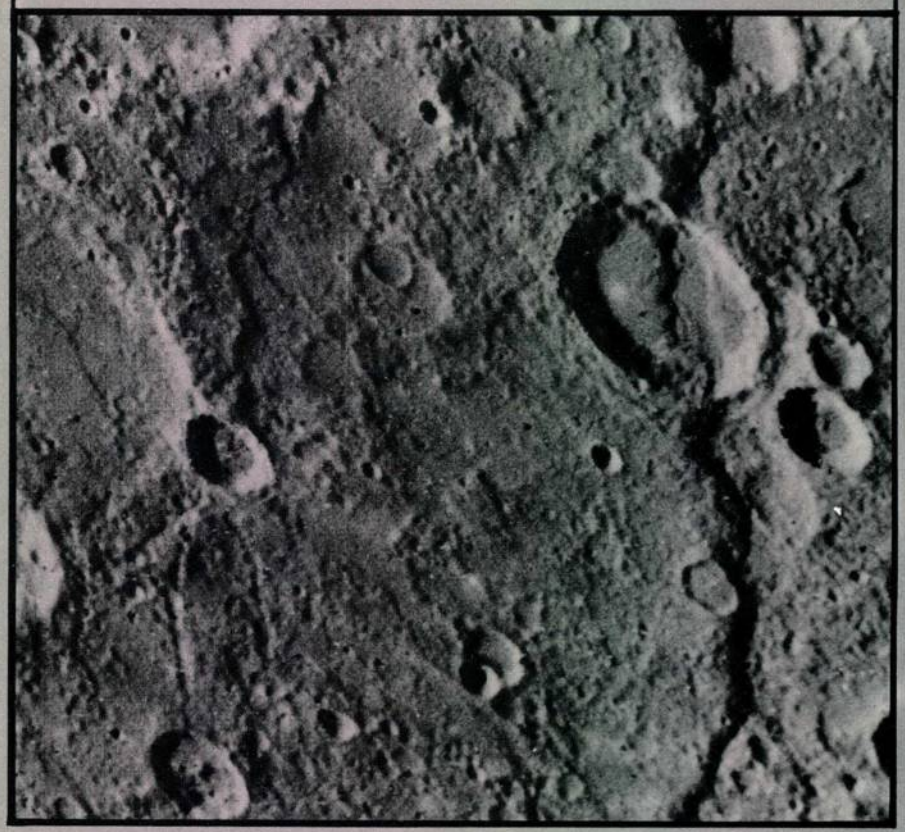
However, if all goes well, everyone will be happy because this second flyby will be a photographic mission at an ideal distance to give a large number of useful views of the south polar region of Mercury and other areas that were not well photographed on the first mission. Then if the spacecraft is still functioning upon swinging around the sun and returning for a third encounter with Mercury, mission controllers hope to target it within 500 miles of the night side of the planet in March, 1975. After this third pass the spacecraft would be flung into an orbit of the sun that would be too distant from Mercury to allow any further encounters.

So if all goes well, the spacecraft will far exceed its expectations and once again underline the tremendous return that unmanned spacecraft are capable of making on a relatively reasonable investment — in this case, under $100 million.

Here are some examples of the results that have come from refinement from the first pass of Mercury by Mariner 10:

A team of 21 scientists and technicians from Stanford University, the California Institute of Technology, the Massachusetts Institute of Technology and the Jet Propulsion Laboratory have released their analysis of radio tracking data from the encounter on March 29, 1973. Perturbations in the path of the spacecraft yield a mass for Mercury of 0.05528 Earth masses, which is very close to the accepted value. In addition, the timing of radio signals as the spacecraft passed behind Mercury allowed a very accurate determination of diameter. The planet is 3,030 miles in diameter in the cross section where the spacecraft flew. It is not believed that the planet deviates very much from a sphere so this figure can probably be considered an average diameter. The team's calculations also reveal the density of Mercury to be 5.44 times the density of water which, along with the other figures derived in this analysis, is pretty close to the values determined from Earth based observations.

300 Mile Ridge on Mercury



NASA Photograph

A unique scarp over 300 miles long that cuts through two huge craters on the surface of the planet Mercury is believed to be the result of "compressive stresses that occurred early in the planet's history", according to Mariner 10 scientists. The scarp is over a mile high in places and is the object of intensive study by Mariner 10 experimenters because this and similar features may provide significant clues to the origins of other Mercury features. The larger crater that is cut by the scarp is about 35 miles in diameter. The photograph was taken by Mariner 10 during its first approach to Mercury on March 29, 1974.

Can Local Supernova Affect Earth Life?

What would happen on this planet if a supernova occurred relatively close to us — say 100 light-years away? Would lethal radiation flood Earth and extinguish life? Astronomers have examined this concept ever since the true nature of a supernova was understood back in the 1930s.

A supernova is a monstrous explosion that marks the death of a star. The fury of the eruption flings an expanding shell of matter away from the site of the cataclysm and at the same time very high energy particles called cosmic rays are injected into space. A supernova remnant will continue to produce cosmic ray particles for thousands of years. A heavy dose of cosmic rays probably would have an effect not unlike a dose of radioactivity.

However, studies conducted over the last few decades have shown that the calculated cosmic ray doses would not be high enough to have killed the dinosaurs, whose extinction has always fascinated mankind. So the matter was shelved.

In a recent issue of *Science*, however, M. A. Ruderman of Columbia University suggested that cosmic rays from a nearby supernova would indeed affect life on this planet, but indirectly. Here's what would happen:

The supernova cosmic rays would increase production of nitric and nitrous oxides in Earth's upper atmosphere. These two gases would very quickly combine with ozone, the gas that now forms a protective blanket by absorbing lethal ultraviolet light from the sun.

With the ozone removed, we would be exposed to all the damaging effects of solar ultraviolet light — such as an enormous increase in skin cancer from severe sunburn. Another effect would be massive changes in mutations of viruses in the atmosphere as a result of the increased ultraviolet bombardment. Human mutants would likely increase as well.

A nearby supernova occurs, on the average, once every 100 million years or so. (By nearby, astronomers mean less than 300 light-years away.)

Has such a supernova occurred? Previous studies of extinctions of dinosaurs and other earthly life forms have discounted the cosmic ray dose theory, but what about mutation or extinction by severe ultraviolet dosage? Is it possible that major changes in the course of life on this planet can be traced back to supernova explosions? Ruderman's calculations suggest that this may be the case.

What would be do today if such a supernova occurred? We'd probably have to move underground to air conditioned abodes where we would be protected from the ultraviolet light and sheltered from the large numbers of strange new viruses that would be floating around.

But there's no sense worrying about it. The next nearby supernova could be tomorrow, or in the year 99,000,000 A.D.

Runaway Pulsar

A pulsar is believed to be the remnant of the core of a massive star that destroyed itself in a supernova explosion. The pulsar's rapid rotation and immense gravitational and magnetic fields warp emitted radiation into a lighthouse-like beam.

These beams are observed on Earth once during each pulsar rotation. They range in frequency from 30 times per second for the Crab nebula pulsar, to one pulse every several seconds. The different rates of pulsations for different pulsars are believed to be results of their ages — as they get older they slow down.

Pulsars are often described as rotating neutron stars and as such are incredibly compact objects about 10 miles in diameter containing about the same amount of material as is in our entire sun. The compacting of so much matter into such a small area occurs in a very short time span during the supernova explosion. The explosion rips off the outer layers of the star and implodes the core to form the pulsar.

This implosion would likely happen in an asymmetrical fashion — that is, one side of the core of the star that is about to become a neutron star may have slight variations in its mass distribution. These would be magnified immensely during the gravitational acceleration toward the final collapse and stabilization at the neutron star stage. This asymmetrical aberration would tend to fling the resulting pulsar at high velocity from its original location — at least according to theory.

And now the theory has been proved — at least in one case, according to R. Manchester, J. Taylor and Y. Y. Van of the University of Massachusetts. Pulsar PSR-1133+16 has been observed to be speeding through space at about 850,000 m.p.h. — which is at least 10 times faster than the average pace of a normal star and exceeds the velocity of practically every star observed to date.

This pulsar is believed to be 400 light-years distant, but at the speed it is traveling it could cover the width of the solar system in less than a year. That's speedy enough to take it out of the spiral arms of the Milky Way in less than a million years. And it would keep going since the galaxy's gravitational attraction is not sufficient to hold on to the tiny celestial hot rodder.

So it seems that the vast void between the galaxies at least contains something — the tiny cinders of once brilliant suns.

Mercury Atmosphere Defined

Along with all the other unknowns about Mercury, the existence of an atmosphere on the innermost planet has long been subject to speculation. Soviet astronomer Nikolai Kozeyrev reported a meager hydrogen atmosphere around Mercury on several occasions over the past decade or so, but these observations were never confirmed. The results from Mariner 10 announced recently by a team of astronomers from Kitt Peak National Observatory and Harvard University paint a picture of an atmosphere so thin that it could never possibly be detected from Earth using present day equipment.

Mercury's atmosphere is only a few billionths the density of the atmospheric blanket of this planet. Other elements of lesser abundance that were detected by the experiments were hydrogen, oxygen, carbon, argon, neon and xenon. To an observer on the surface of Mercury, the existence of the atmosphere would be impossible to detect without special instrumentation.

The experimenters also reported an unexpected "emission seen as the spacecraft flew by Mercury". So far this has gone unexplained, but they're still working on it.

Surface of Mercury Like Moon

Through the telescope, Mercury is an extremely difficult target because of its nearness to the sun and its small size. A phenomenal increase in our knowledge of the solar system's smallest planet came as a result of the Mariner 10 mission which produced photographic and other data revolutionizing our knowledge of the innermost planet (see pages 4-16, June 1974).

One of the instruments on board Mariner 10 was an infrared radiometer used to measure the temperature of the surface layer of the planet. The temperature range on the nighttime side (previously only guessed at) was measured to range from 240 degrees below zero just after sunset to a low of 300 degrees below zero in the deep nighttime portion of the planet just after its midnight. The alternating periods of 88 days of sun and 88 days of darkness mean that the temperature ranges on Mercury exceed 1,000 degrees and its surface soil is subjected to these vast changes over its total 176 day rotation period.

Commenting on results gleaned from the infrared radiometer experiment, a team of Mariner 10 scientists recently reported, "The Mariner 10 radiometer observations of the night side of Mercury are consistent with the presence of a moonlike layer of insulating silicate dust constituting at least the upper tens of centimeters of the soil." This implies that the first few feet, at least, of the soil on Mercury is very similar to that which was kicked around, dug up and brought back to Earth by the Apollo astronauts. Such a finding was not entirely unexpected as the meager information available to earthbound astronomers suggested that this would be the case.

Distant Pluto Photographed

Photograph by Dana Patchick

Photograph by Steven Wheatcraft

Two photos of the 14.3 magnitude planet Pluto show the distant world as only a speck of light. The photo at left is a half hour exposure on Kodak 103aF film taken through a guided 4-1/4 inch f/5 reflector on March 23, 1974. The second photo was taken April 17 on Tri-X film through an eight inch Celestron telescope guided for 22 minutes. Pluto was seen visually through this telescope on 18 occasions.

Mercury's Magnetic Field

Up until the flight of Mariner 10, no one would have predicted a magnetic field for Mercury. Unlike Earth and Jupiter whose intense magnetic fields deflect and trap charged particles from the sun, Mercury was believed to be without such a field. The basis for this belief was that magnetic fields were the result of rapid planetary rotation, and Mercury's extremely slow rotation period of 176 days (or 59 days with reference to the stars) would judge against a magnetic field.

A five member team of scientists associated with the magnetic field observations experiment on Mariner 10 have recently concluded that Mercury does in fact have a weak magnetic field. This is inferred from observation of the charged particles from the sun being mildly deflected from the region of the planet.

Although their conclusion is still considered preliminary, they believe it is the most logical way to explain the observations. But it imposes the reevaluation of the concept that planetary magnetic fields are the result of rapid rotation. Did Mercury rotate much more rapidly at some previous time, and is this a remnant field? Or is it due to something else?

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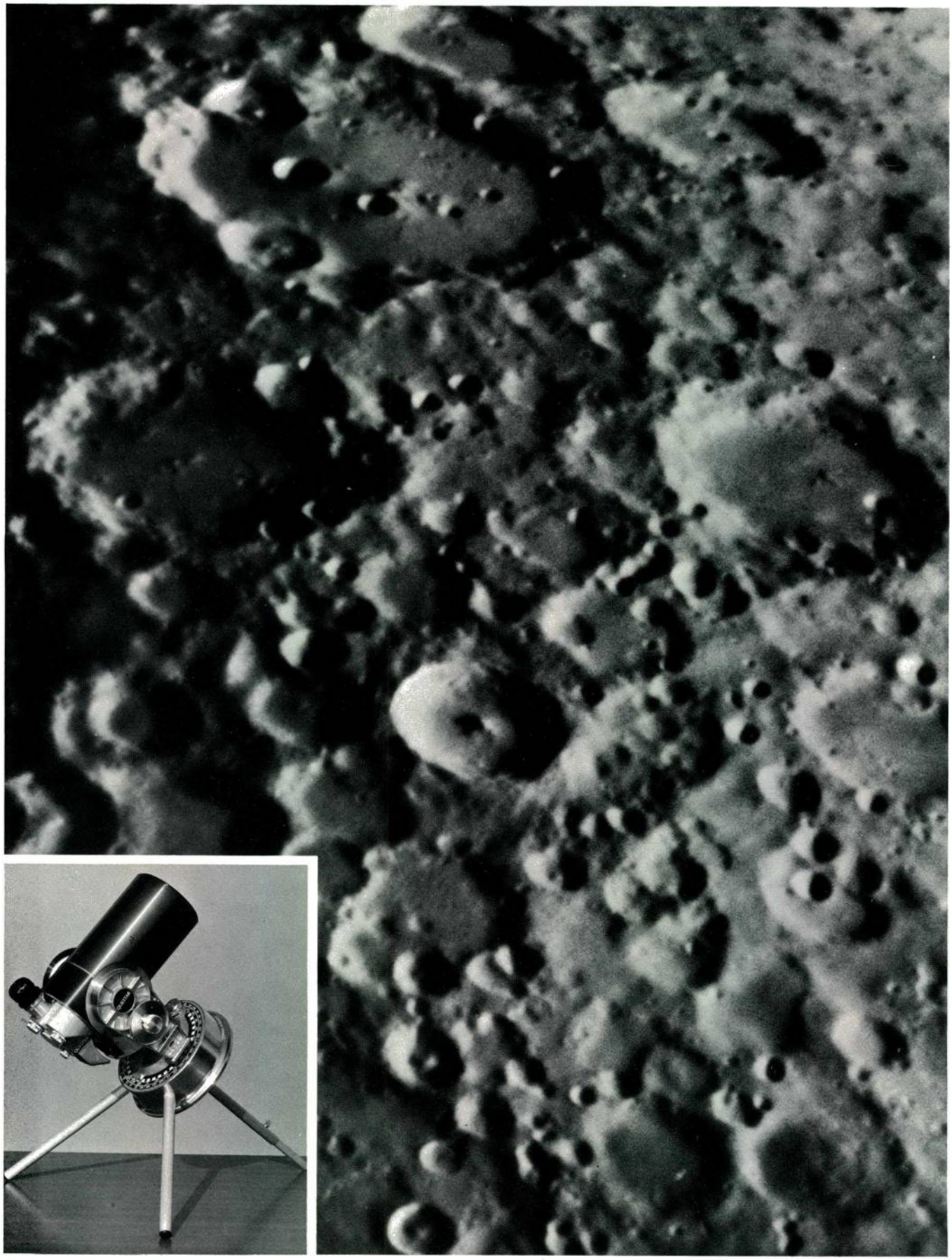

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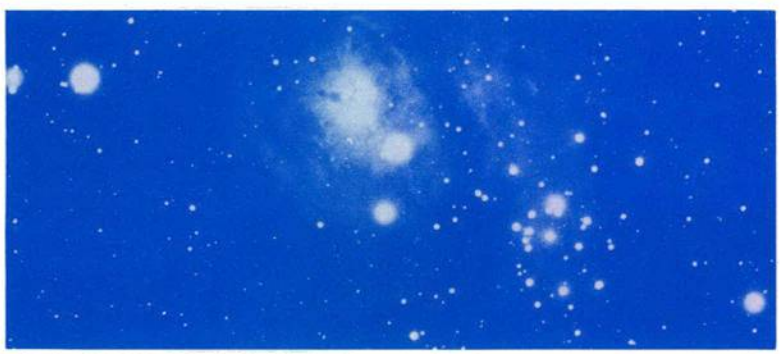

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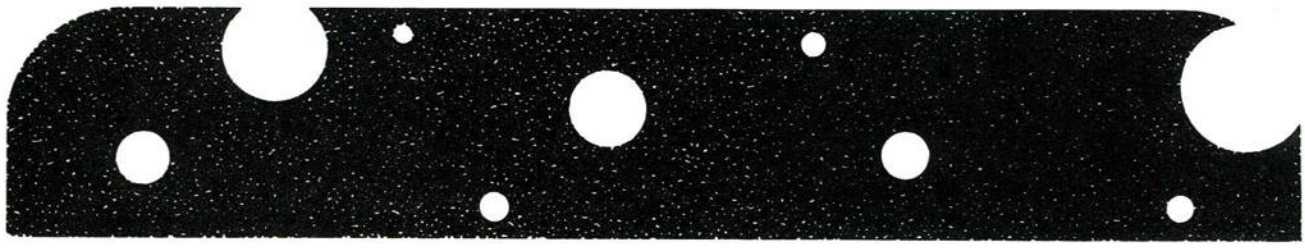


STELLAR FRONTIERS

The Dumbbell, the Owl and the Eskimo

by
Gerrit L. Verschuur

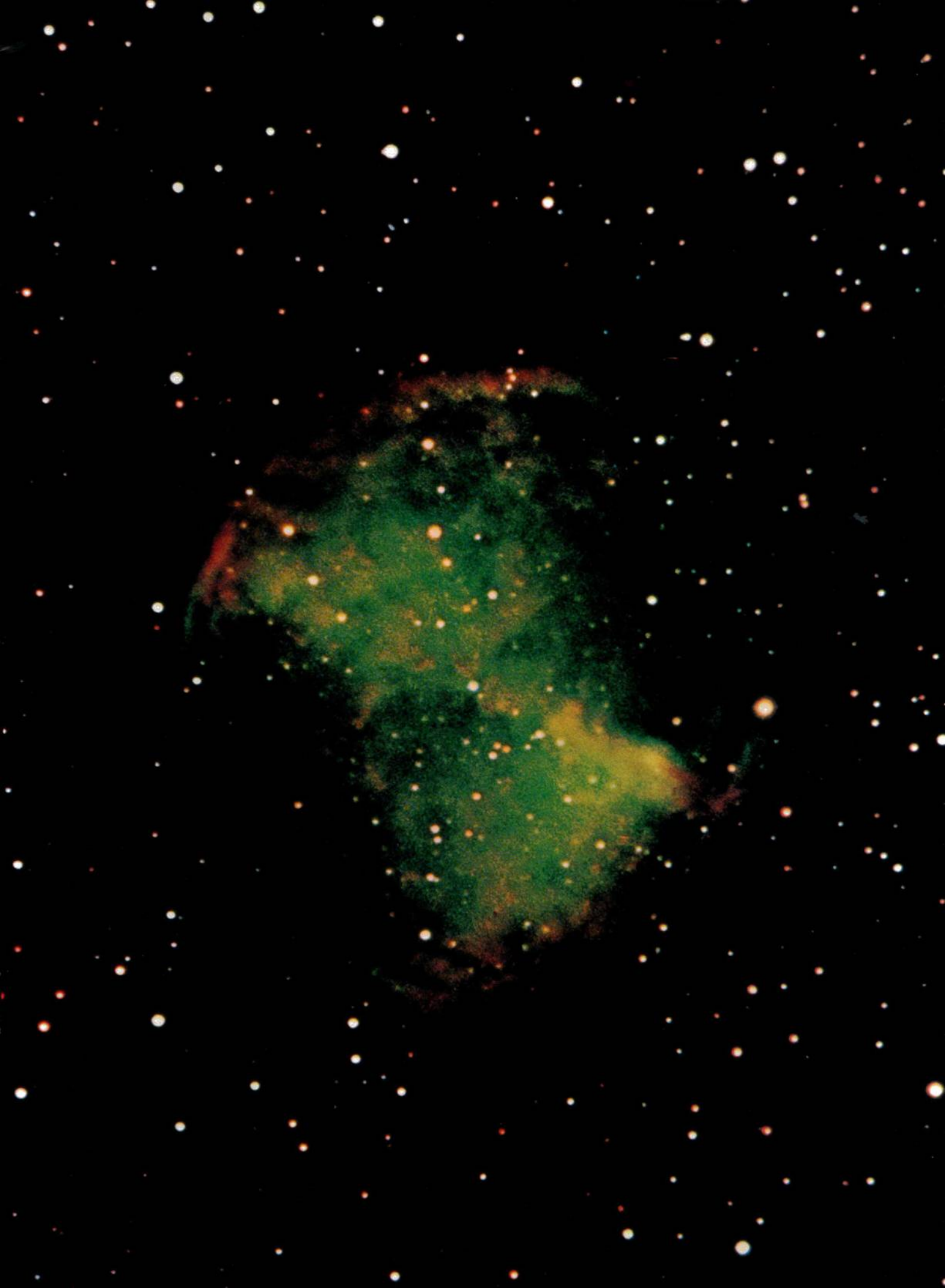
This is not the title for some mystery thriller or a new fairy tale; these are names of planetary nebulae. There are a few others like the Ring and the Helix; but besides these, most planetary nebulae have the usual sterile astronomical type names ranging from NGC-7027 through designations such as K3-50, M1-11 and BD 30-3639, which hardly invoke any images in the mind's eye. But as the more descriptive names suggest, planetary nebulae are among the most dramatic and beautiful of all sky objects.

These celestial oddities were originally called planetary nebulae because their outlines appear disklike in most photographs and to the eye, and seemed to resemble the disks of planets. However the name is a complete misnomer since they are in no way related to planets. Instead, they are large diffuse spherical clouds of gas that have been puffed off by hot, dying stars, and heated by those stars so that they radiate their own light and radio waves.

There is a definite difference between planetary nebulae and the apparently somewhat similar gas then radiates visible light, infrared radiaemission nebulae such as the Orion nebula. Emission nebulae are clouds of hot gas surrounding very hot, young stars — clouds that were left over after stars formed within them. On the other hand, planetary nebulae are much smaller clouds of gas ejected by stars as they approach the end of their lives. The sun is expected to have a planetary nebula shell around it in about six billion years, after it has passed through the red giant stage (see diagram on page 13, August 1974). The only similarity between the two types of nebulae is the fact that the gas is heated by the ultraviolet light from the stars themselves, and the hot

The intricate detail of the famous Dumbbell nebula is only seen photographically — it looks much more like its name in a six inch telescope. The Dumbbell is the most prominent planetary nebula in the sky. To find this eighth magnitude celestial "blob", run a line from Gamma Lyrae through Albireo and extend it an equal distance. The diffuse seven minute wide object will be clearly evident in a three inch or larger telescope. It will appear pale green, much less intense than in this color correct photo taken through the 120 inch telescope. The origin and significance of this peculiar class of objects is outlined in this article.

Lick Observatory Photograph



tion and radio waves as a result of collisions between particles in the heated gas.

The central star in a planetary nebula may be as hot as 200,000 degrees and normally is a small white dwarf. Despite their enormous temperatures they only emit as much total energy as the sun because the stars themselves are not much larger than Earth. The surrounding gas shell that forms the nebula is heated to about 20,000 degrees and the gas is fully ionized (that is, electrons are stripped away from the atomic nucleus).

The size of the planetary nebula itself can range from a small fraction of a light-year in diameter to about one light-year across. Their angular sizes on the sky range from a few seconds of arc to 1/2 degree across, depending on age (young ones are the smallest) and distance. It is thought that a typical planetary nebula is about 20,000 years old.

In trying to understand the processes that occur inside these nebulae and their odd range of shapes, astronomers observe at many different wavelengths. Radio and optical observations are combined with data collected at the specific wavelengths of atoms such as oxygen and nitrogen. For example, the planetary nebula known as NGC-7027 has an infrared picture exactly the same as the radio picture, while the optical picture looks different. The reason appears to be that the optical picture is partly affected by obscuration by interstellar dust between us and the nebula, while the radio and infrared radiation pass unimpeded right through the dust. However, while the radio signals come from the hot ionized gas, the infrared radiation is known to originate from hot dust particles. Since the two pictures of the nebula look alike the hot dust and hot gas must be mixed in the same volumes of space. We might be watching dust particles actually being injected into space from a star — particles that will ultimately blend with the dust already in the rest of space.

Photographs of planetary nebulae taken in the light radiated by different atoms in the nebulae often show that these objects look quite different at different wavelengths. This is because the physical conditions required to make one atom (or ion) radiate are different from those that cause another atom (or ion) to radiate. Study of this phenomenon reveals that there are small blobs of high density and relatively cold matter situated inside most planetary nebulae. These small blobs are so dense that the ultraviolet radiation that usually heats the gas cannot penetrate to the inside of these small condensations. In fact, the globules can cast a shadow within the nebulae so that matter beyond these

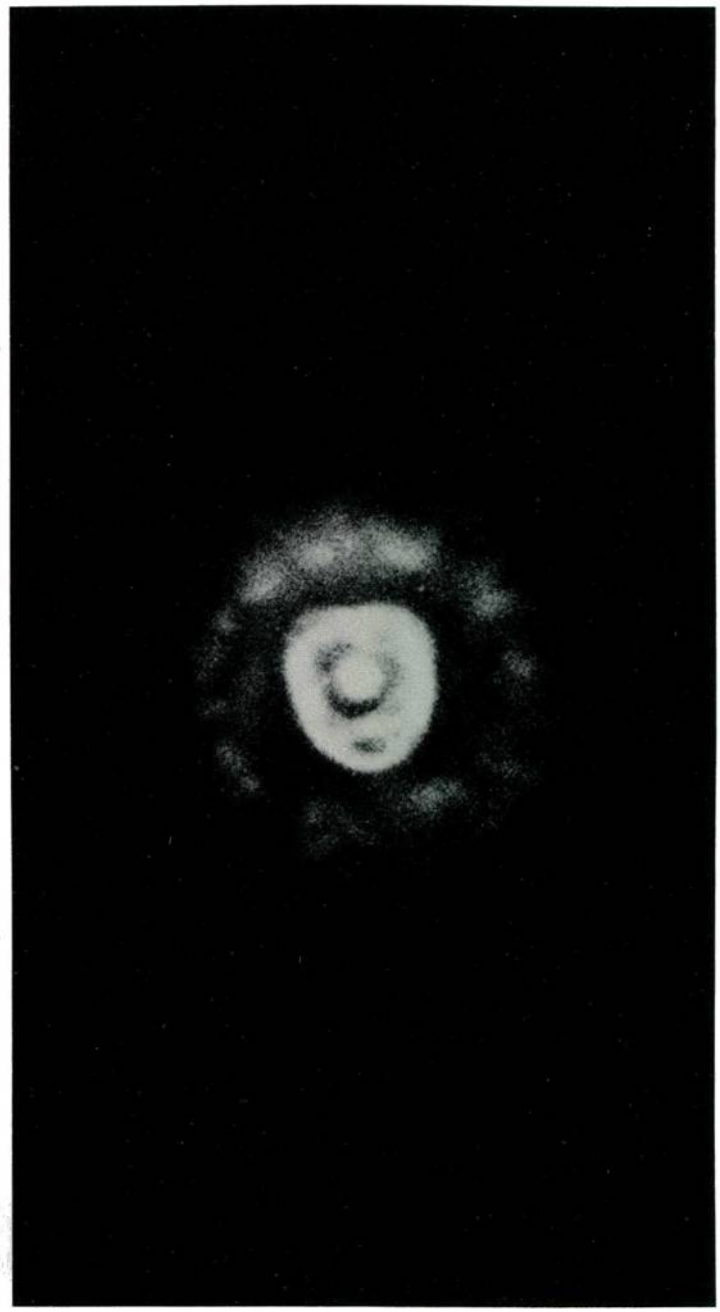
Ring nebula (M-57) Photograph by Leo Henzl

small blobs, on the side away from the star, might be cooler than unshaded matter. Thus the nebulae can take on all worts of weird shapes, such as is seen in the Eskimo nebula.

Why should such small blobs or concentrations form? After all, we think of planetary nebulae — such as the Ring nebula — as being nicely symmetrical objects. Indeed, at first sight most planetary nebulae are symmetrical and often round, although somewhat elongated. This elongation appears to have something to do with surrounding magnetic fields that influence the way the ejected shell of matter expands. Let's take a close look at what does happen to the expanding shell of matter as it is ejected.

In the beginning the star might find itself

Owl nebula (M-97) Hale Observatories Photograph



Eskimo nebula (NGC-2392) Hale Observatories Photograph

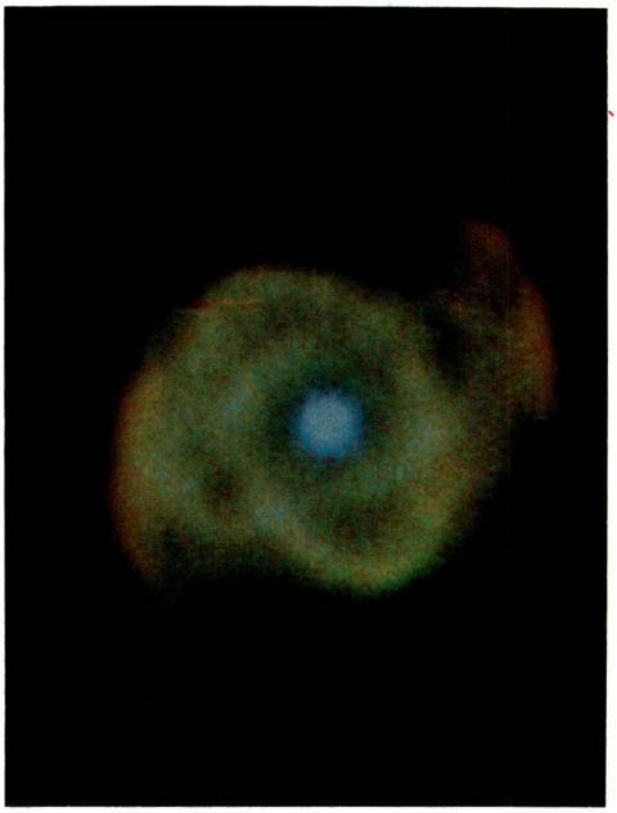
Three huge spherical puffs of gas, all with superhot central stars, are typical representatives of nearby planetary nebulae. The Eskimo nebula, so-called because of the "parka hood fur" around the "face", is one of the youngest known planetaries. Its distance is believed to exceed 3,000 light-years. The Owl nebula is the most distant of the group at 10,000 light-years, while the Ring is about 1,400 light-years away. Of these three famous planetary nebulae, only the Ring is an easy object for smaller telescopes. Located nearly midway between Gamma and Beta in Lyra, the Ring nebula's donut appearance is easily seen in a four inch telescope.

in a cloud of interstellar matter — the common neutral hydrogen clouds that exist throughout interstellar space, even around the sun. When the star ejects its shell of gas, the energy in this hot gas is great enough to force the surrounding cold interstellar gas (about 200 degrees as compared with 20,000) outward like a piston. As the expanding shell gets larger, the ultraviolet radiation that heats and ionizes the gas has to travel farther and farther from the star. This radiation will ultimately get used up on its way out to the edge of the nebula just to be able to maintain the high temperature in the nebula. Around this time the pressure of certain areas of the surrounding interstellar gas will start to balance the pressure within the planetary nebula and the shell becomes unstable. It's something like the effect you get when you push in the sides of a balloon as it's being inflated. Parts of it are prevented from expanding while other areas bubble out. So it is with the planetary nebula

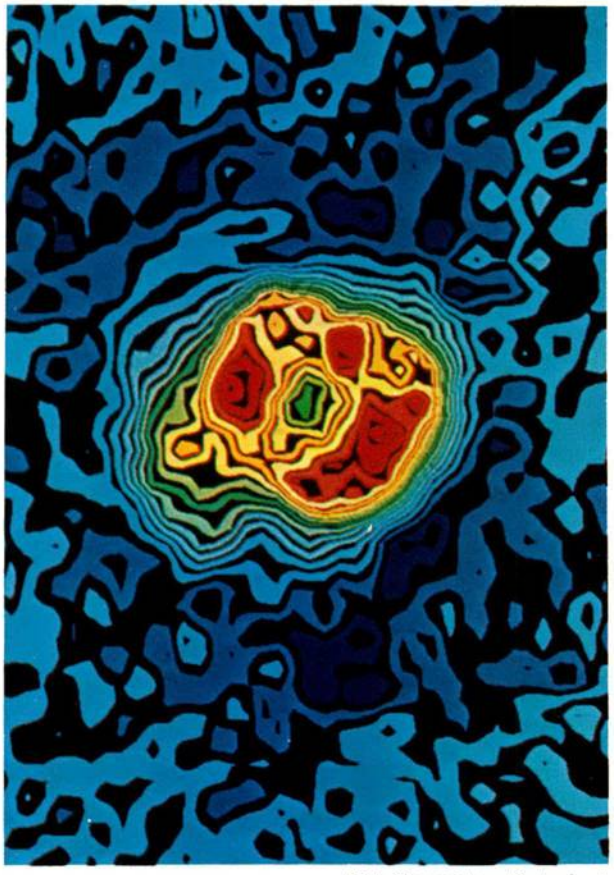
Photograph by Orien A. Ernest

The Helix nebula is believed to be the nearest of the several hundred known planetary nebulae even though it is over 400 light-years away. Despite the fact that this sphere of gas and dust contains more matter than Jupiter, it is exceedingly diffuse since it is spread over a cubic light-year. The large photo, taken with the 200 inch telescope, shows the intricate detail of the nebula — especially the countless globules of denser matter that look like comet heads (see text for details). The overall brightness of the Helix nebula, also called NGC-7293, is calculated to be sixth magnitude. But because it is about 1/2 the width of the full moon, this brightness is diffused over a vast area making it a difficult and unspectacular haze in binoculars or rich-field telescopes.

Hale Observatories Photograph



Photograph by Carl Bignell



Lick Observatory Photograph

The eighth magnitude planetary nebula NGC-6543, about 1.5 trillion miles wide and over 3,000 light-years distant, is seen here in two ways. The upper photo clearly shows the nebula's swirl shape resembling a spiral galaxy. Below is a colorful "radio map" that can reveal much about the object's composition and structure. By studying planetary nebulae, astronomers hope to obtain a clearer picture of what seems to be a distinct stage in the evolution of a solar type star.

shell. As soon as one spot is pushed in a bit more than any other spot around the shell, the whole thing starts to get distorted rather quickly.

Such a distortion quickly spreads and is known as an instability. As a consequence a lot of spikes of hot matter will push out into the surrounding gas cloud while the zones of cold matter knife inward into the hot nebular shell. As these hot and cold spikes of matter rush past each other they further distort and start to form small condensations of dense matter, globular in shape. Calculations have shown that as many as 100,000 of such small globules, or blobs, may form. About half of the matter in the nebula may end up in such condensations. It is these condensations that are so dense that they are shielded from the ultraviolet radiation from the star. They will therefore shade other parts of the nebula. As the nebula ages and ultimately ceases to exist after 100,000 years, hundreds of thousands of small globules will be fed into the interstellar medium.

Clearly, the shape of any given planetary nebula will differ depending on its stage of evolution and the distribution of globules within it. Then, since different radiations originate in the shadowed regions as compared to the illuminated parts of the nebula, the planetary nebula will look different when examined in the light from different atoms and ions.

One of the strangest types of planetary nebulae are those that have an apparent helical shape; that is, they look like parts of a helical spring seen on end. The Helix nebula, NGC-7293, is one such object while NGC-6543 is another. It has been found that parts of NGC-6543 are moving away from the central star at about 7,000 m.p.h. both on the far and near side of the star. This is faster than most planetary shells expand and must be due to youthful vigor. Various other calculations confirm this and give an age of only 1,000 years. In another 10,000 years it will look like a typical amorphous planetary nebula showing little structure.

Despite the large number of dramatic shapes exhibited by planetary nebulae, some are featureless. The **Palomar Sky Atlas** (showing stars to 23rd magnitude) has dozens of planetaries that look like blemishes on the plates! On the other hand, objects such as the Ring nebula are dramatically beautiful and can quite easily be seen with small telescopes.

Where are most of the planetary nebulae in our galaxy? It turns out that they are where most of the stars are — in the densest regions of the Milky Way. There may be as many as 50,000 planetary nebulae in the galaxy, which — although a large number — is only a very small fraction of the 150 billion stars in the entire Milky Way galaxy.

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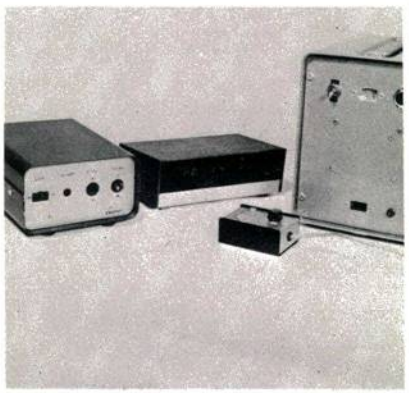

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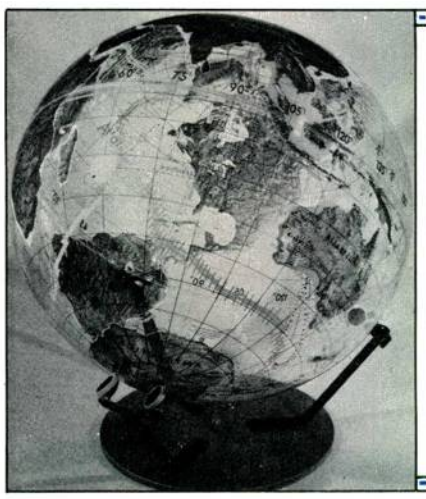

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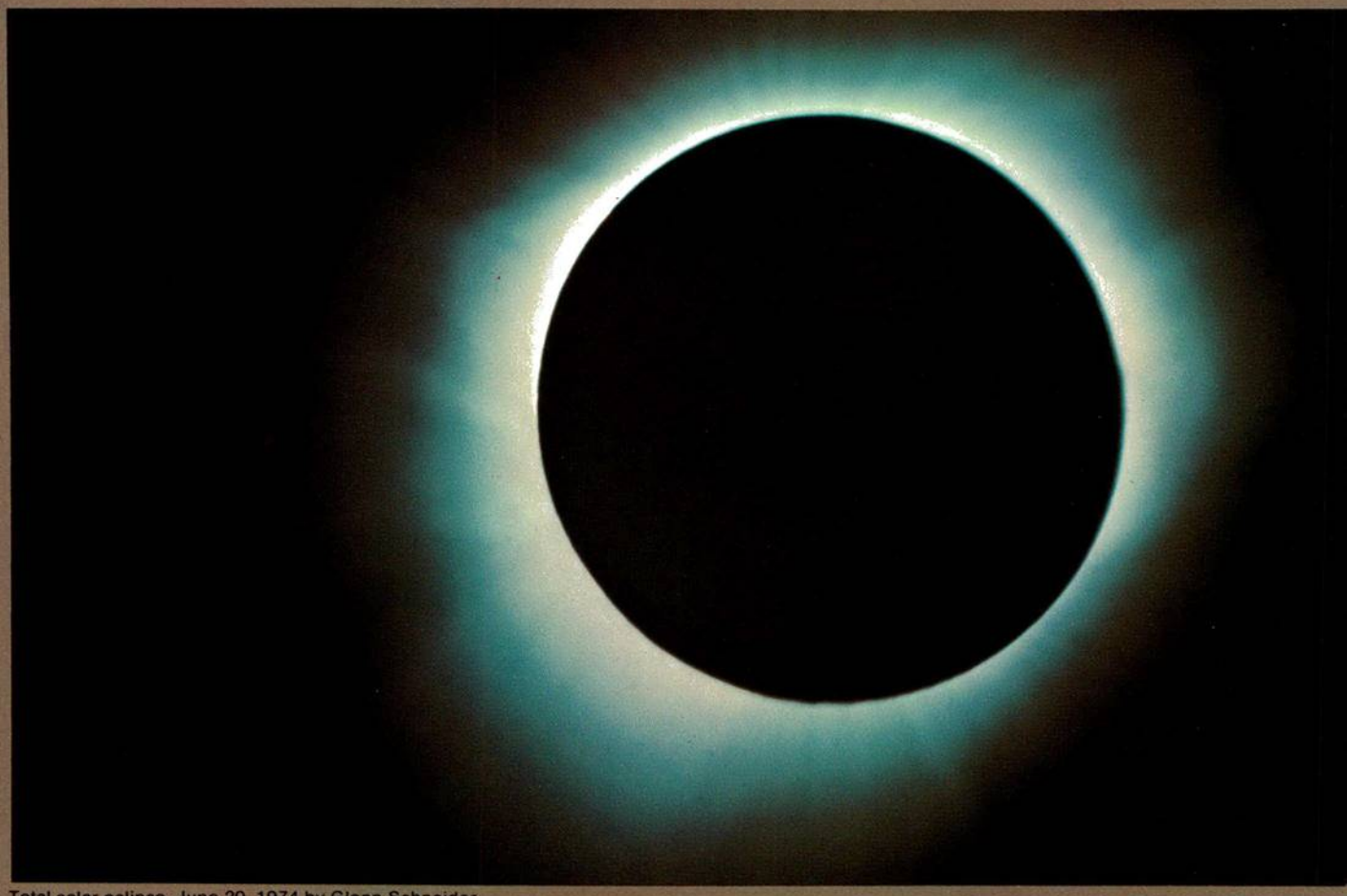


Total solar eclipse, June 20, 1974 by Glenn Schneider

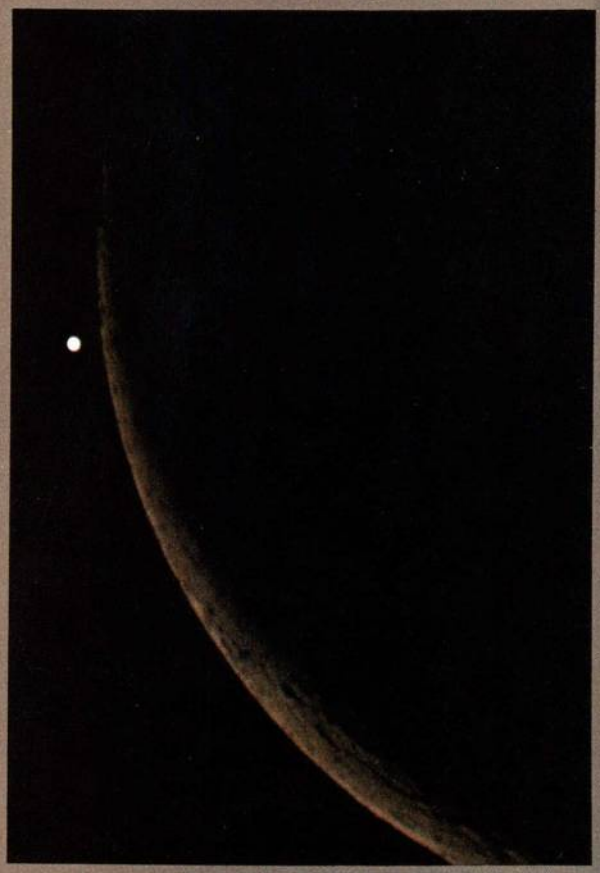
Early morning aurora, July 6, 1974 by Ronald Parmentier

This occasional department is devoted to some of the best color astrophotographs we receive over a period of months. They are generally made by amateurs with easily available equipment. Payment for use of these photos is $10.00 each. For details, see pages 40 and 41.

Early morning aurora, July 6, 1974 by Thomas C. Bretl

STAR GALLERY '74

Partial lunar eclipse, June 5, 1974 by Janos Papp



Occultation of Venus by Bradley W. Timerson

SEPTEMBER

What does magnitude mean? The beginning astronomy enthusiast is confronted with a plethora of new terms that can be unfamiliar and frustrating. In some astronomy books, the definitions of these terms include the use of other terms that are equally unfamiliar, and the novice remains bewildered. If magnitude has been giving you some problems, read on and we'll try to straighten them out.

Stars in each constellation are indicated, in order of brightness, with the Greek Alphabet.

α	Alpha	η	Eta	ν	Nu	τ	Tau
β	Beta	θ	Theta	ξ	Xi	υ	Upsilon
γ	Gamma	ι	Iota	o	Omicron	ϕ	Phi
δ	Delta	κ	Kappa	π	Pi	χ	Chi
ϵ	Epsilon	λ	Lambda	ρ	Rho	ψ	Psi
ζ	Zeta	μ	Mu	σ	Sigma	ω	Omega

Map Centered on 43° North Latitude

MAGNITUDES

- Zero
- First
- Second
- Third
- Fourth
- Fifth

OBJECTS

- Open Clusters
- Globular Clusters
- Diffuse Nebulae
- Galaxies
- Double Stars
- Variable Stars

Star Dome approximates the sky as it appears at 10 p.m. Local Daylight Time on the first day of the current month. The same constellations are visible one hour earlier on the 15th. To use this constellation finder, hold it overhead so the compass points line up with North, South, East and West in your backyard or viewing area. For example, to find constellations in the southern part of the sky hold the chart in front of you so the South compass point faces the southern horizon. Repeat this procedure for East, West and North. Since only the brighter stars are represented in this map, you should be able to trace out the geometrical shapes of the constellations with ease. To find planets, asteroids, etc., visible among the current month's zodiacal constellations, refer to the planet finder in Sky Almanac.

STAR DOME

Map by Raymond G. Coutchie

There are several kinds of magnitude — absolute magnitude, bolometric magnitude and others. But the one that we're going to discuss is apparent magnitude — usually referred to simply as magnitude.

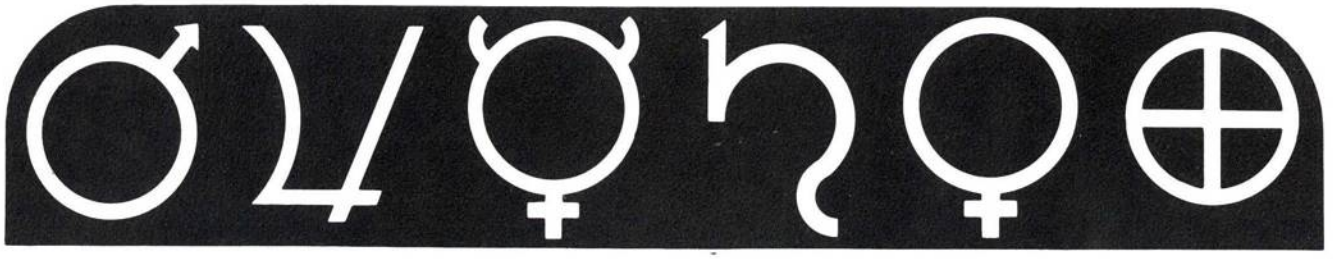
The magnitude of a star is a measure of its brightness, and the unit dates back to the 2nd century B.C. when Greek astronomer Hipparchus was compiling a catalog of stars. He decided to categorize them according to their brightnesses. He set aside about 20 of the brightest stars and called them first magnitude stars. The faintest stars that could be seen with the unaided eye were put into the sixth magnitude category. The remainder were arbitrarily distributed in between first and sixth.

Modern astronomers have inherited this system and have determined, by direct measurement of the brightness of the stars, that the average first magnitude star is 100 times brighter than the average sixth magnitude star. When it came to measuring the brightnesses of the 20 so-called first magnitude stars, it was found that some of these were much brighter than the average. Vega and Arcturus, for example, are so much brighter that they were put in a classification above first magnitude — zero magnitude. Sirius, the brightest of all stars in the nighttime sky, is magnitude -1.

Using a photometer, astronomers can measure the magnitudes very precisely. Sirius turns out to be -1.4, Arcturus is -0.1, and Aldebaran, +1.1. As other examples, Polaris is just about in the middle of the second magnitude class at +2.0 while Epsilon Canis Majoris, also known as Adhara, just misses being a first magnitude star at +1.5.

Most stars have a steady light output like the sun — virtually the same from one year to the next. However a few stars are variable. Betelgeuse in the constellation Orion varies a few tenths from its average of +0.4, and a few other stars have changes in their brightnesses too. But the greatest regular variations in magnitude among bright objects belong to the planets which experience tremendous changes in distance from Earth as both they and Earth navigate their orbits around the sun. Mars is the best example of this. When it is closest to Earth it reaches magnitude -2.8, but when farthest away it drops down to +2.0. This means that Mars is 70 times brighter when it's at its near point compared to its far point.

The brightest object in the night sky apart from the moon is Venus, which can reach a magnitude of -4.4 (more than 10,000 times brighter than a sixth magnitude star). So the range in brightness of objects in the night sky is considerable, but it all falls into place when you get used to the measuring tool called magnitude.



Jupiter Dazzles Late Summer Sky

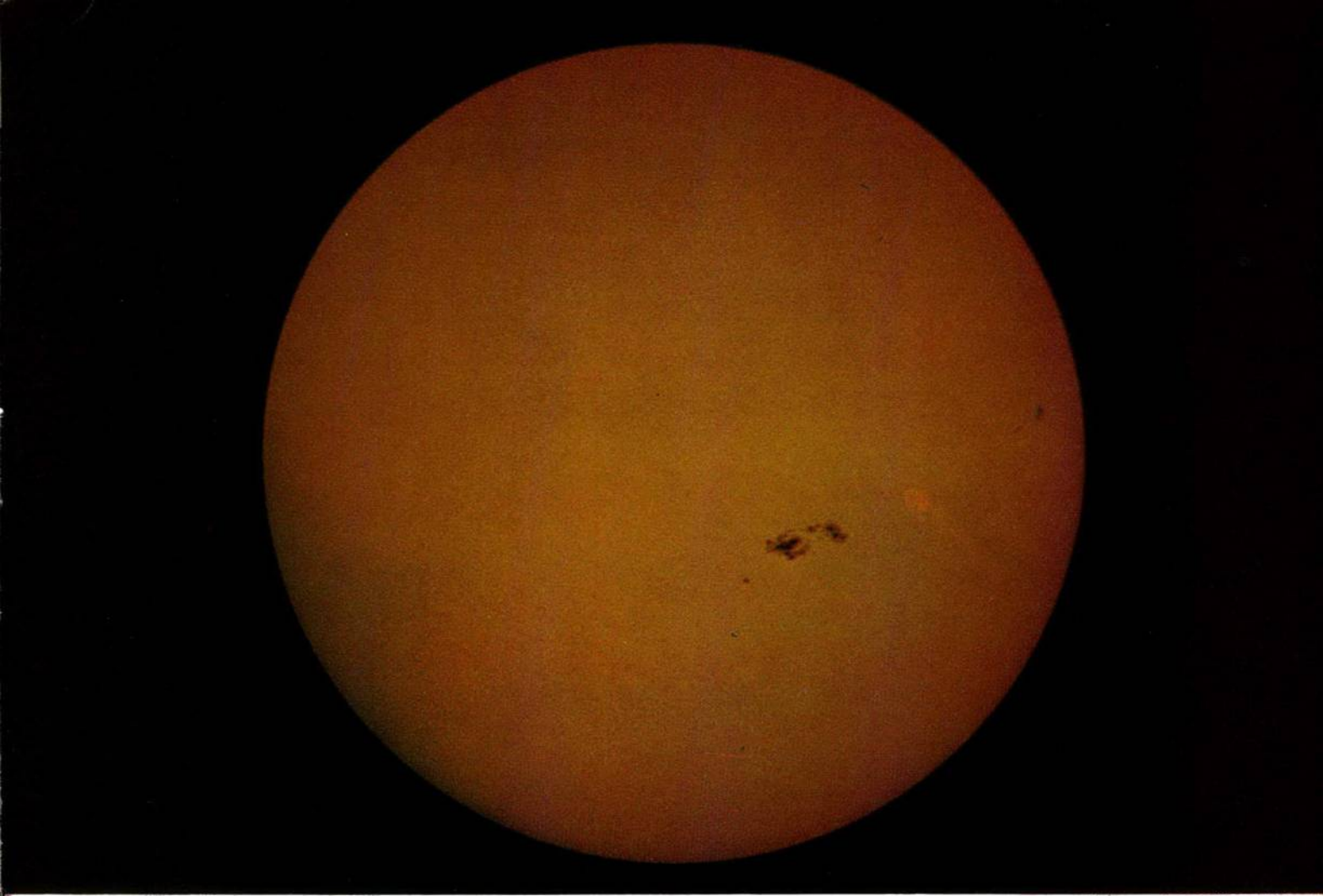
The only planet with us this month is Jupiter — but if we could have only one planet, Jupiter would be the one that we would choose. It's spectacular to the unaided eye at magnitude -2.5 — far brighter than anything else in the evening sky, and in the sky for the entire night. Through a small telescope, the moons of Jupiter are a continuous fascination; in a large telescope (as described in Gazer's Gazette), there is a wealth of interesting phenomena to captivate the observer.

Jupiter

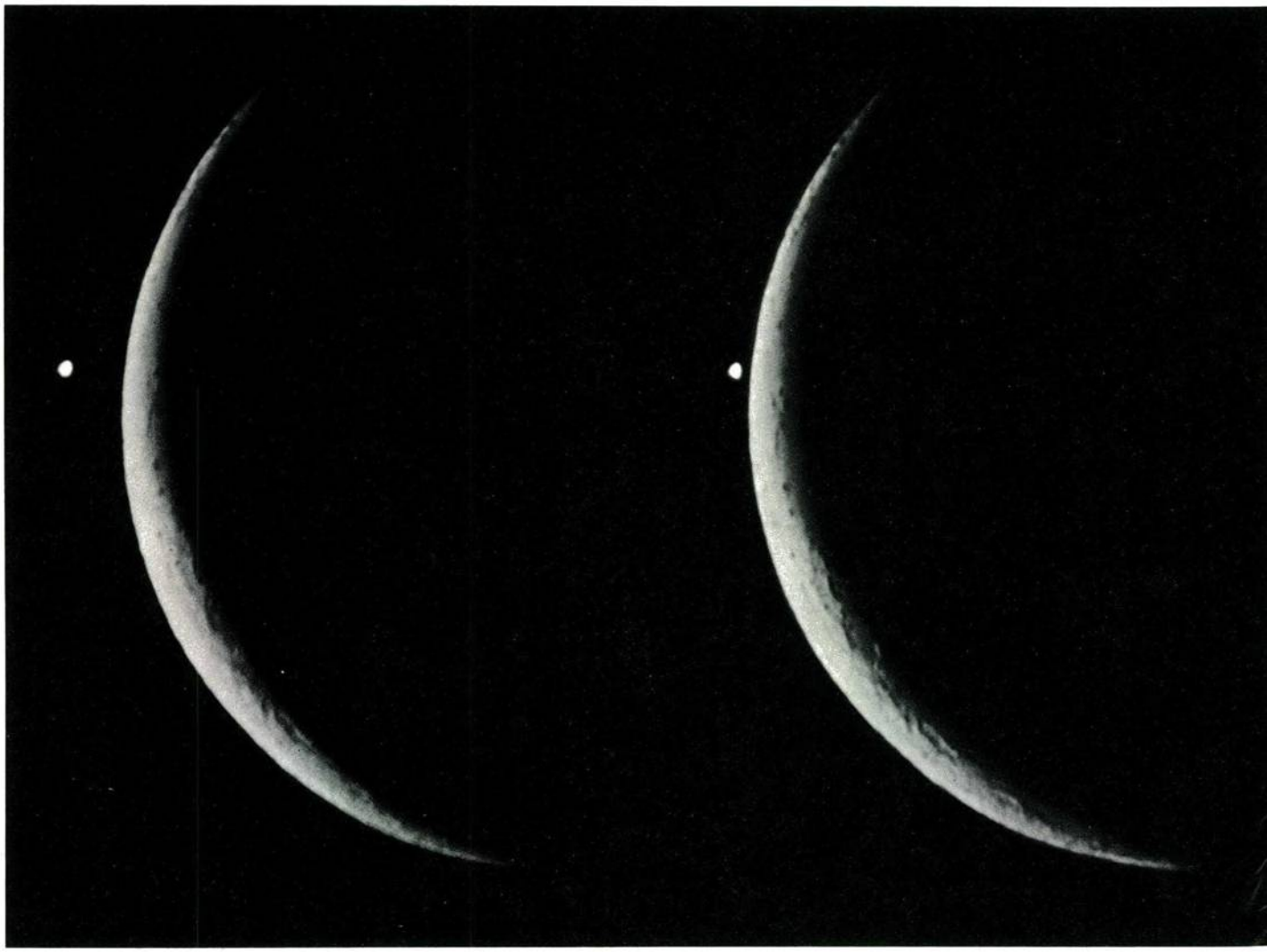
On Sept. 5 Jupiter is at opposition; that is, it appears opposite from the sun in our sky and at the same time is at its closest point to Earth for the year. Jupiter's distance at that time is 370 million miles — but for the first two weeks of September the distance changes little, making this the prime period this year to turn your telescope toward the solar system's largest world.

If you're not sure where to look for Jupiter, it's the easiest thing in the sky to find. Just walk

A rare massive eruption spewed millions of tons of solar material off the face of our star on July 4, 1974. The full disk photo, taken through a six inch reflector telescope, shows the location of the giant sunspot associated with the disruption. The close-up photo, taken with a special five inch solar patrol telescope in Boulder, Col. shows much more detail including the flare itself. Patrick McIntosh of the National Oceanic and Atmospheric Administration suggested that the eruption may have been visible in an ordinary, small, properly filtered telescope. The flare was responsible for the auroral activity seen two nights later (photos, pages 30 and 31). Space Environment Laboratory NOAA Photograph



Photograph by Richard Albrecht



outside, face southwest any evening in September and a superbrilliant, yellowish-white dazzling "star" will greet you. It looks much different from any typical star though. Besides being brighter than even the brightest star, Jupiter (like the other planets) does not twinkle. The reason for this seemingly unusual behavior is simply that the planets are so much closer to us and their light is so much stronger that they penetrate through the minor variations in Earth's atmosphere — whereas the fragile point sources of the stars are much more affected by turbulence in our blanket of air. So stars twinkle and in general, planets do not.

This year Jupiter is nearly as close to Earth as it can ever get, and for this reason appears larger in the telescopes than it has in a number of years. The disk of Jupiter is 49.5 seconds of arc in apparent diameter across its bulging equator and 46.2 seconds from pole to pole. These dimensions are maintained for the first two weeks of September. Jupiter then recedes to 378 million miles by the end of the month; its equatorial diameter shrinks to 48.3 seconds, and the polar diameter is down to 42.1 seconds of arc. The implications of this large apparent size are detailed in Gazer's Gazette.

For the rest of 1974 Jupiter remains within the boundaries of the faint zodiac constellation Aquarius, marking about the midpoint between the stars Fomalhaut and Markab (Alpha Pegasi). Because Earth is passing the slowly moving Jupiter, the big planet appears to be moving from east to west in the sky even though its orbit is carrying it from west to east. This can be noticed by watching Jupiter this month as it moves from the left (east) of Lambda Aquarii to the right of that star. Lambda is a fourth magnitude star in the constellation Aquarius. A drawing of Jupiter made in July, 1974 appears on page 49, and a photograph of Jupiter made in the same month is on page 53.

Saturn

Around midnight some of the winter constellations — Orion, Taurus and Gemini — begin to make their appearance above the eastern horizon. In the middle of Gemini is the ringed planet Saturn.

Now at magnitude+0.1 Saturn is moving into

Photographs by Bob Padykula

The passage of the moon in front of Venus on the morning of July 17 was described as breathtaking and spectacular by some of our readers. Here the events leading up to the actual complete occultation of Venus are photographically documented as seen from Clifton, N.J. All are 1/60 second exposures through a Celestron 8 telescope on Kodak Tri-X film. From left to right, the times (EDT) are 4:49, 4:52, 4:54:25 and 4:54:45. The 86 percent illuminated disk of Venus — looking like a tiny brilliant gibbous moon — could be seen until the last sliver of it was covered by the moon. The moon covered Venus in about 20 seconds as the times above indicate.

fairly good position for late night observing. Later this year it will be in a more convenient location for the evening sky observer.

The solar system's most stunning telescopic object appears (from ring tip to ring tip) a little less than the width of Jupiter in the same telescope with the same eyepiece. The full width of the rings at the beginning of September is 39.0 seconds of arc, and as Earth and Saturn move nearer one another, the apparent width of the rings increases to 41.1 seconds of arc by the end of the month. During the same interval, the globe of the planet itself increases from 17.3 seconds to 18.2 seconds in equatorial diameter. Saturn, like Jupiter, is noticeably bulged at the equator because of its rapid rotation and several thousand mile thick atmosphere. Consequently the polar diameter is 1.8 seconds less than the figures quoted above.

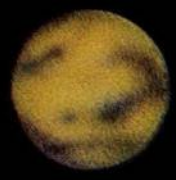
During your exploration of Saturn you might notice some stars in the field immediately around it. The brightest of these is probably not a star at all but Saturn's largest moon Titan. Titan will be at its maximum distance east of Saturn on the 8th and 24th, and an equal distance west of it when it swings around to the other side of its orbit on Sept. 16 and again on Oct. 2. Titan, at magnitude 8.5, can be followed completely around the planet in a 60mm refractor. That same telescope will clearly show the rings of the planet and perhaps even the division in the rings (which is shown well in the photographs in this month's Photography in Astronomy).

Venus

Venus, always the brightest planet, is now at magnitude -3.4 and can still be glimpsed about 45

Ⓒ Ceres

Sept.	1	15
R.A.	23h02m	22h50m
Dec.	-23°05'	-24°07'
Mag.	+7.3	+7.3



Ⓐ Mercury

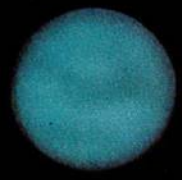
Sept.	1
R.A.	11h36m
Dec.	+3°30'
Dia.	5.0"
Mag.	-0.3

Ⓑ Mercury

Sept.	15
R.A.	12h53m
Dec.	-6°41'
Dia.	5.5"
Mag.	+0.3

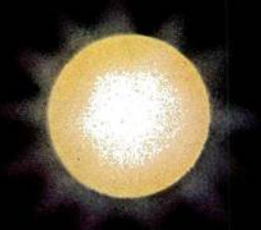
Ⓜ Mars

Sept.	1	15
R.A.	11h36m	12h09m
Dec.	+3°33'	-0°07'
Dia.	too near sun	too near sun
Mag.	too near sun	too near sun



Ⓝ Neptune

Sept.	15
R.A.	16h22m
Dec.	-19°57'
Dia.	2.4"
Mag.	+7.7



SUN

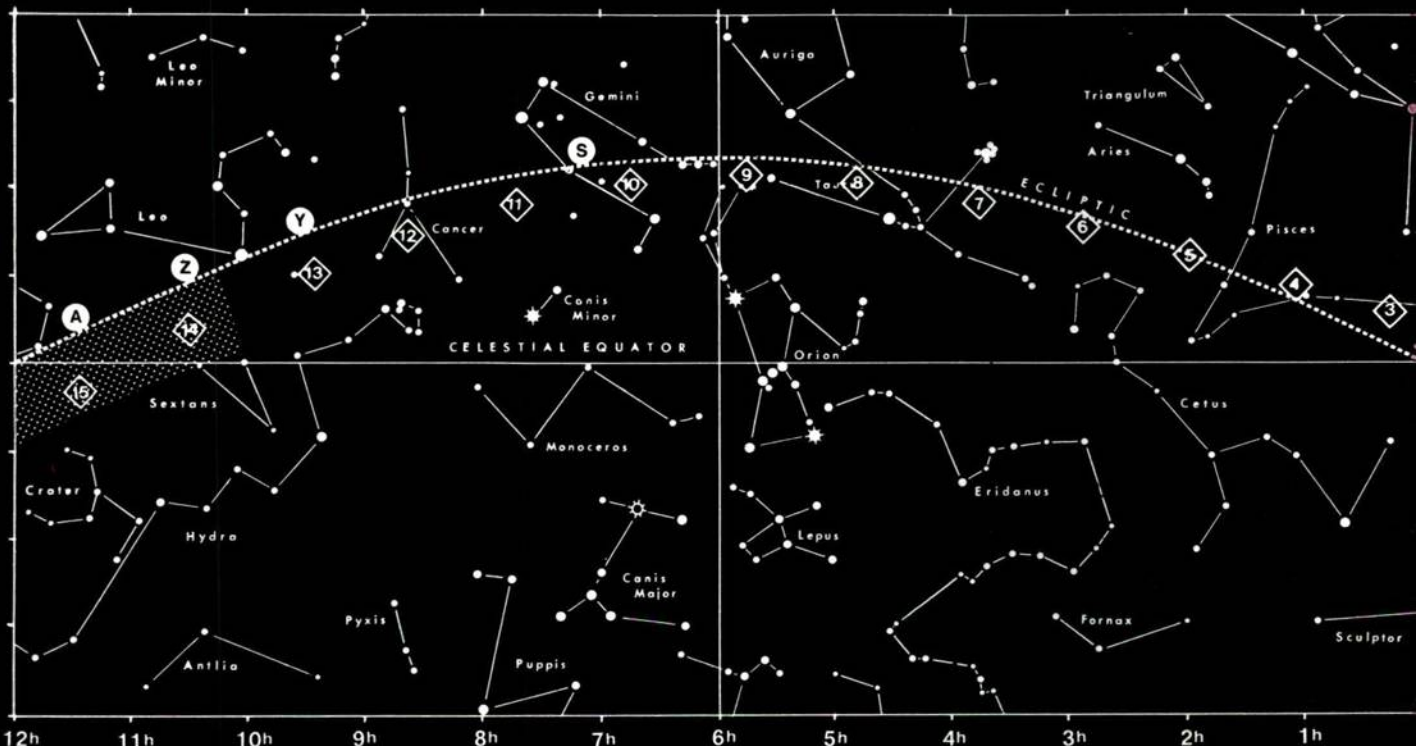
The sun is within the stippled zone throughout the month. Planets and stars near this area are not easily seen.

Ⓢ Saturn

Sept.	1	15
R.A.	7h08m	7h14m
Dec.	+21°59'	+21°51'
Dia.	17.4"	17.7"
Mag.	+0.4	+0.4

Ⓤ Uranus

Sept.	15
R.A.	13h37m
Dec.	-9°32'
Dia.	3.6"
Mag.	+5.8



Map by Raymond G. Coutchie

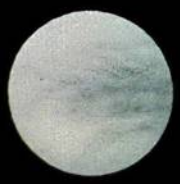
The chart shows the positions of the moon, planets and brightest asteroids for the current month. Letters within the circles correspond to the letters beside each object in the data section above the map. Additional information about each object is given there. **R.A.** = right ascension and **Dec.** = declination, the two coordinates used to locate astronomical objects. The general coordinate system is indicated around the edge of the map. **Mag.** = magnitude, a

Ⓥ Vesta

Sept.	1	15
R.A.	14h19m	14h44m
Dec.	-9°23'	-11°59'
Mag.	+7.2	+7.3

Ⓙ Jupiter

Sept.	1	15
R.A.	23h01m	22h54m
Dec.	-7°52'	-8°35'
Dia.	49.5"	49.3"
Mag.	-2.5	-2.4

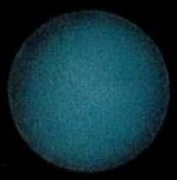


Ⓨ Venus

Sept.	1
R.A.	9h39m
Dec.	+15°06'
Dia.	10.4"
Mag.	-3.4

Ⓩ Venus

Sept.	15
R.A.	10h46m
Dec.	+9°17'
Dia.	10.1"
Mag.	-3.4



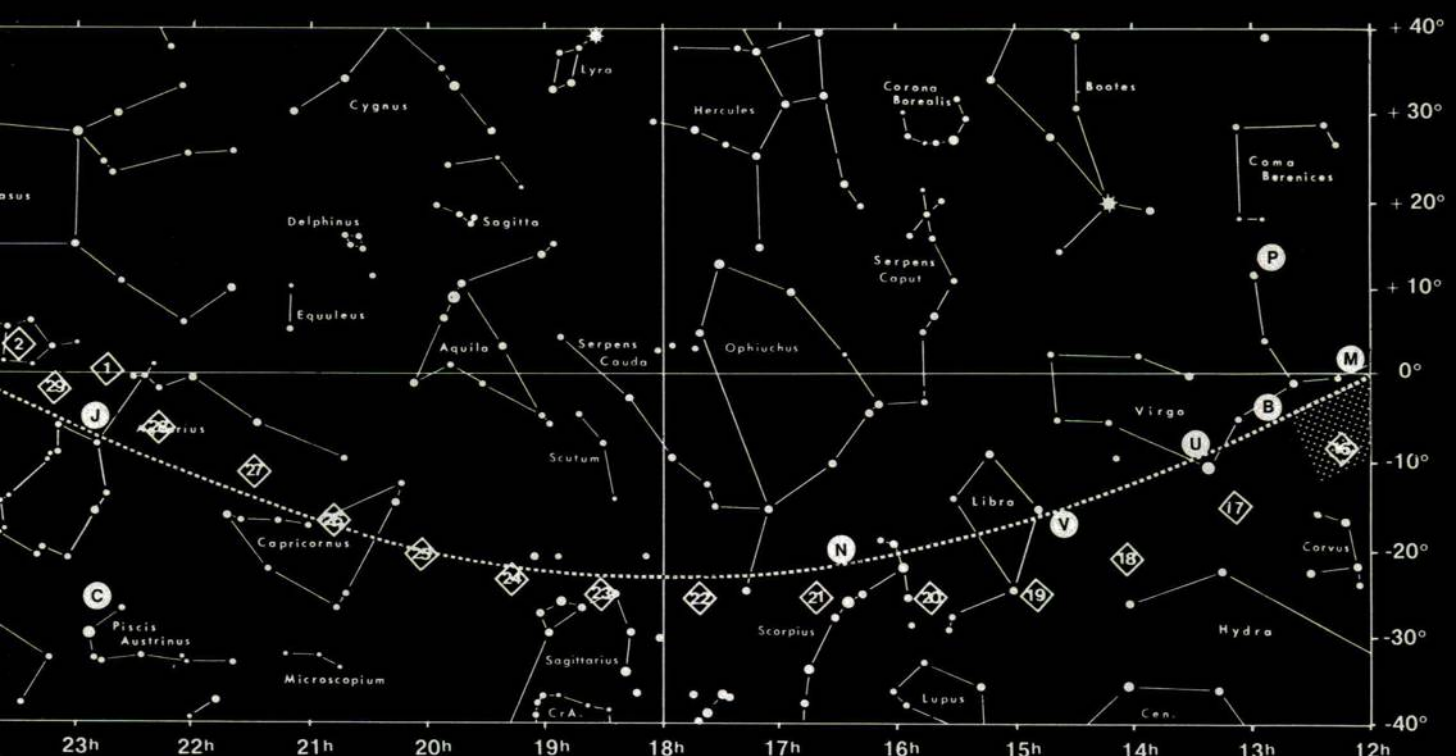
Ⓟ Pluto

Sept.	15
R.A.	12h48m
Dec.	+12°31'
Mag.	+14

First Quarter
Sept. 23

Full Moon
Sept. 1

Last Quarter
Sept. 9



measurement of the object's brightness. (The minus magnitudes indicate very bright planets.) **Dia.** = the planet's apparent diameter in seconds of arc. The diamonds with numbers within them indicate the position of the moon for each day of the month; the numbers correspond to the dates. Positions of the planets are for the 15th of the month except for Mercury and Venus which are shown on both the 1st and 15th.

Artwork by Victor Costanzo

minutes before sunrise almost due east. But since Venus is on the far side of its orbit and appears relatively close to the sun, it is both an uninteresting telescopic object and a fairly difficult visual object compared to its good position earlier this year.

Mars

The fourth planet, which about a year ago was dominating the evening sky, is now on the far side of its orbit and will remain too close to the sun for observation for the rest of 1974.

Mercury

The solar system's innermost and smallest planet is playing its usual role of hiding in the sun's glare although it does peek out during the last two or three days of the month and the first few days of October. However its position for North American observers is so poor that observations with the unaided eye or telescope are not worth the effort. The end of May and beginning of June was the time in 1974 for Mercury observing. It won't be conveniently in the evening sky again until next spring.

Pluto

Several of our observers have reported seeing Pluto in fairly moderate sized telescopes. Steven Wheatcraft of Coshocton, Ohio reports observing Pluto on numerous occasions in a eight inch Celestron telescope. The 14th magnitude planet is shown in two photographs on page 17 , one of which was taken with a 4-1/4 inch telescope.

Major Aurora Observed

A spectacular display of northern lights — the aurora borealis — was witnessed by thousands of residents of north central and northeastern North America on the night of July 5-6. ASTRONOMY received reports of "stupendous arcing curtains of pulsating color" from readers in Illinois. Other equally ecstatic comments came from observers in Wisconsin, Iowa, Michigan, New York, Ohio, Pennsylvania and elsewhere. Both aurora photos on pages 30 and 31 were approximately 20 second exposures on High Speed Ektachrome; more will be printed next month.

The display was partly masked by the nearly

SATELLITES OF JUPITER SEPTEMBER

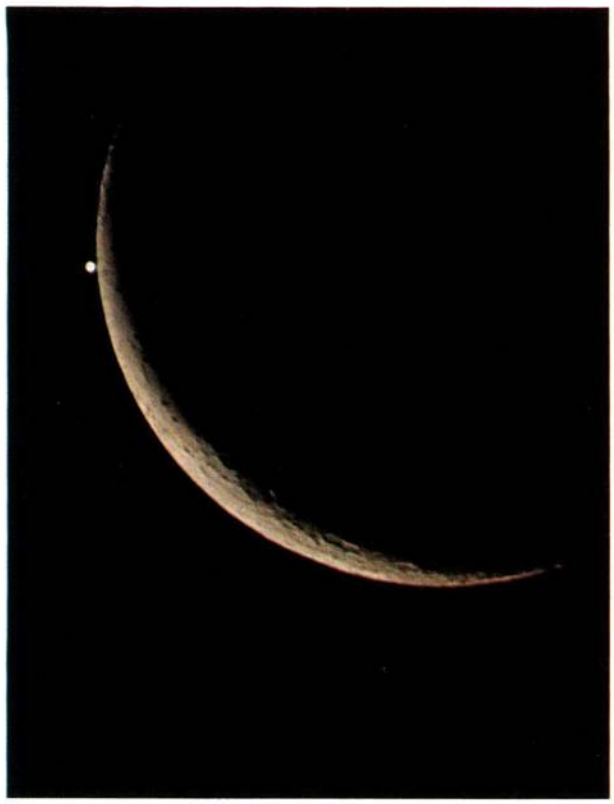
1	40312		16	41302	
2	43102		17	43201	
3	32401		18	4310	
4	31024		19	43012	
5	0324		20	2043	
6	20134		21	2043	
7	21034		22	01234	
8	01324		23	13024	
9	31024		24	32014	
10	32014		25	31204	
11	3104		26	30124	
12	43012		27	1034	
13	4203		28	2103	
14	42103		29	40123	
15	40123		30	4102	

The four major satellites of Jupiter orbit the giant planet in periods ranging from just under 2 days to 17 days. They can be seen to change position from night to night. Sometimes their motions become evident after only a few minutes' observation. Only a small telescope is required to detect all four of the satellites and several can frequently be seen in rigidly held binoculars. This table shows the approximate positions of the moons at about 10 p.m. (EDT) on the evenings indicated. First column on the left shows the date. Second column of numbers identifies the moons and their positions relative to Jupiter's disk. (1 = Io; 2 = Europa; 3 = Ganymede; 4 = Callisto, and 0 = Jupiter's disk.) The third column approximates a telescopic view of the satellites' positions. The orientation of the satellites is shown inverted as seen in a standard astronomical telescope.

SATELLITE SHADOWS ON JUPITER

Date	Satellite	Transit begins (EDT)	Transit ends (EDT)
Sept. 2-3	2	11:44 p.m.	2:34 a.m.
4	1	4:45 a.m.	7:02 a.m.
5-6	1	11:14 p.m.	1:30 a.m.
10	2	2:20 a.m.	5:09 a.m.
13	1	1:09 a.m.	3:25 a.m.
14	1	7:37 p.m.	9:54 p.m.
17	2	4:56 a.m.	7:45 a.m.
20	1	3:04 a.m.	5:21 a.m.
20	2	6:15 p.m.	9:03 p.m.
21	1	9:32 p.m.	11:49 p.m.
23	3	7:33 p.m.	10:56 p.m.
27	1	4:59 a.m.	7:16 a.m.
27	2	8:51 p.m.	11:38 p.m.
28-29	1	11:28 p.m.	1:44 a.m.
30	1	5:19 p.m.	8:13 p.m.
Sept.30-Oct.1	3	11:35 p.m.	2:57 a.m.

1 = Io
2 = Europa
3 = Ganymede
4 = Callisto



Photographs by Bradley W. Timerson

The moon covered Venus at about 5:00 a.m. EDT June 17, 1974, and 40 minutes later revealed the planet again in the brightening dawn sky. Photos were made on Ektachrome-X film through an eight inch f/7 Newtonian telescope from Newark, N.Y. The first exposure was 1/8 second while the dawn exposure was 1/30 second. Many observers throughout the northeast reported good observing conditions for this rare event.

full moon but the intensity of the auroral arcs and streamers was still clearly seen. Especially unusual were the rapid pulsations of segments of the lights — the ghostly curtains seemed to be blown by some cosmic wind.

Aurorae are caused by charged particles blasted from the region of a flare on the sun. The particles become trapped in Earth's magnetic field and quickly funnel down toward the magnetic poles where they interact and excite the molecules of the upper atmosphere. These molecules emit light thus producing the northern and southern lights. Based on surveys at major planetariums, it has been estimated that 75 percent of the adult population in the northern portions of the United States have never seen an auroral display.

Despite the appearance of occasional huge flares such as the one shown on page 35, there is only a probability that an aurora will occur two days later when the associated particles reach our planet. Sometimes no aurora is seen; sometimes a super display is witnessed. In any event this is one phenomenon that is even too fast for our *Instant-News* service.(*Instant-News* is a new service for the sky observer. As a paid subscriber to ASTRONOMY you can get immediate notice of any unusual astronomical event — such as a new comet or nova that is, or might become, brighter than seventh magnitude. Detailed charts with magnitudes of nearby stars will accompany a full description of the new object. Send 10 self-addressed, stamped, long envelopes and $2 to *Instant-News,* ASTRONOMY, 757 N. Broadway, Suite 204, Milwaukee, Wisc. 53202.)

Star Gallery Details

The partial lunar eclipse of June 5, 1974 was seen in Asia and Europe, but not North America. At maximum eclipse, 83 percent of the moon was immersed in Earth's shadow. The photo on page 31 (lower left) was taken at 22:42 Universal Time (6:42 p.m. EDT, June 5) about 20 minutes after maximum. The bright rayed crater Tycho is prominent near the lower limb. The photo was taken from Budapest, Hungary where our photographer reported the umbra (dark shadow) as "a dirty, deep brownish color with diffuse edges". A six inch f/8 reflector was used for the 1/30 second exposure on Agfachrome 50-S.

Like the lunar eclipse mentioned above, the total eclipse of the sun was also invisible from North America. Among the small group who did get a good view of it from western Australia were members of the Amateur Astronomers Association of New York — one of whom snapped the photo on page 30 through a 3-1/2 inch Questar telescope. The 1/8 second exposure was taken on Kodachrome 64 film.

1974 TEN YEARS SPRINGER-VERLAG NEW YORK

A Journey Through the Invisible Universe and the World of Radio Astronomy

The Invisible Universe

By **G. L. Verschuur,** University of Colorado, Boulder, Colorado

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1974. 192p. 70 illus.
paper/$5.90
Heidelberg Science Library Volume 20

Galactic and Extra-Galactic Radio Astronomy

Edited by **G. L. Verschuur** and **K. I. Kellermann**
National Radio Astronomy Observatory, Green Bank, West Virginia

This book is concerned with the observational aspects of modern radio astronomy outside the Solar System. It begins where most textbooks on radio astronomy leave off, with a discussion of what is actually known from research in the field. Emphasis is placed on the type of data available and its interpretation. The book is aimed at graduate students and practicing astronomers, but is also suitable for senior astronomy courses.

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ASTRONOMY

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In response to requests from our readers and schools, ASTRONOMY has just published a cumulative index to Vol. 1. This subject index covers August, September, October, November and December, 1973, which includes issue Nos. 1 through 5. Index to Vol. 1 is available for $1.00 each, including handling and first class postage.

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Asimov on Astronomy
by ISAAC ASIMOV

238 pages, hardcover, $8.95
Doubleday & Co., Inc. (1974)

The imagination of a science fiction writer, the descriptive powers of a popular college professor, and the comprehensive knowledge of a seasoned science journalist — put them all together and you get Isaac Asimov. No one else writes so much on science so well.

This book is a collection of essays on astronomy that appeared originally in **The Magazine of Fantasy and Science Fiction** between 1959 and 1966, so the material is not new. However the feature article this month is a slightly revised chapter of this book and it obviously has suffered very little since the time it was written (1959).

So it is with most of the 17 essays in this volume — they represent popular science writing at its best and should appeal particularly to newcomers to the world of astronomy. The scope of the book encompasses a great variety of topics from asteroids to galaxies, and there are many black and white photos sprinkled throughout to augment the text. With a book of this size you can't cover everything. But what Asimov does select, he handles well.

Jupiter — The Largest Planet
by ISAAC ASIMOV

224 pages, hardcover , $5.95
Lothrop, Lee & Shepard (1973)

Writing a book about Jupiter before the arrival of Pioneer 10 last winter was really going out on a limb, but in Asimov's case the limb held. The book is a delightful, clear and incisive description of what we know about Jupiter, and what this implies for the rest of the solar system.

The book is aimed at the "juvenile" market. What this means to most readers is that there are occasional background paragraphs which can be skipped. Do so, however, at your own risk. Asimov is more than a science reporter: He points out, reinterprets, and adds things up to come up with original and surprising thoughts.

The book begins with the discovery of Jupiter, an event that occurred thousands of years ago. Asimov then chronicles the efforts of astronomers to measure and understand the planets — their true paths, distances and sizes. And Jupiter and its own satellite system immediately stood out as unique. (Throughout the book more than 50 tables list most of the interesting things known about Jupiter and its satellites.)

This is more than a children's book. Asimov describes and explains the Kirkwood asteroid belt gaps, the Trojan planets, the Galilean satellites and their peculiarities, the Jovian atmosphere, radio bursts keyed to the position of the moon Io, the wobble in the sun's path caused by the gravity of Jupiter and the implication of that wobble with regard to the discovery of planets around other stars.

Best of all, the book conveys the mystery and excitement of astronomy today. As an introduction for a young reader, or as a review and revelation for older readers, this book is very satisfactory.

The Backyard Astronomer
by ALAN E. NOURSE

118 pages, hardcover, $7.95
Franklin Watts, Inc. (1973)

There have been many beginners' guides to the sky, some more successful and enduring than others. It's hard to achieve that difficult blend of simplicity and hard content that marks the perfect guidebook. In many ways this book reaches that goal.

The author assumes his reader to be a typical high school student who is curious about astronomy and wants to know and see more. The style is simple and direct, but not condescending. The opening chapter introduces the sky for the naked eye and binoculars by describing how to look — rather than what to look at; that comes later. Such basic principles as dark adapted eyes and the apparent rotation of the sky are skillfully handled.

Later the basic constellations are introduced with uncluttered maps. Other naked eye treats such as eclipses of the sun and moon are very well handled, while the planets are skimmed over — perhaps because they are not of immediate interest to the true beginner.

The last half of the book is devoted to selection and use of binoculars and small telescopes. (Part of this was excerpted in the July issue, pages 60-67.) The binocular section is particularly thorough — a wise emphasis since binoculars get short shrift in most beginner's guides.

On the minus side this large format volume lacks any dramatic illustrations in either black and white or color. This was probably done to keep the cost down but one wonders how anyone would be motivated to buy the book after riffling through its rather stark pages of text and line drawings. At least a few photos or drawings of the moon and planets as they appear through binoculars or a small telescope should have been included.

However, **The Backyard Astronomer** gets our nod. If you think of yourself as a "class A" beginner, or know someone who is, then this book is highly recommended.

Books are expensive — especially astronomy books. Seldom is one priced under $5.00, and some cost as much as a two year subscription to this magazine. So great care should be taken to make sure you get the right book for your level of experience and sphere of interest.

That's the purpose of this department — to outline in plain language what a book is about and whether it suits your particular desires for more information. We won't hesitate to point out a book's good and bad features. We're not trying to sell books — we're trying to let you know what's available. This, then, is a sort of consumers' guide to astronomy books.

GAZER'S GAZETTE

Jupiter Looms Into View

Let's, in imagination, place ourselves gently on the edge of a glacier on Callisto, the fourth large moon of Jupiter. Here, 1,170,000 miles from the solar system's largest planet, we get a perfect view of that colossal globe. It's laid out in front of us like a multicolored beach ball suspended in the sky by an invisible string.

As we sit, mesmerized by the quilt of storm riddled clouds that swirl across the face of the 88,700 mile wide world, we soon notice that it is also a rapidly spinning globe. Clouds that only a few minutes ago seemed to be at the center of the planet are now moving out of sight and new ones are sweeping into view. If we had enough time we would calculate that Jupiter rotates completely in about 10 hours. One of the best measuring points is the Great Red Spot — a mysterious oval in the planet's southern regions that only in the last few months has become fairly well understood. According to Pioneer 10 data the spot is a towering vortex of organic-like compounds that is constantly being spewed from some heated atmospheric volcano-like source below. (For details on the nature of Jupiter's atmosphere, see "Planetary Bonanza", June 1974.)

You may wonder why we are describing this hypothetical view of Jupiter from one of its moons. Isn't such a panorama only an imaginary one? Well not quite — you can get practically the view that we've described by using a six or eight inch telescope with an eyepiece giving about 200 magnifications. Of course you'll also need a cooperative atmosphere that will give you a steady view of Jupiter. That combination will place you just a few hundred thousand miles beyond Callisto. How can that be? Right now Earth is about 370 million miles from Jupiter. A telescope magnifying 200 times will in effect bring Jupiter 200 times closer — or stated another way, put you 200 times closer to Jupiter. That places you about 1.8 million miles from Jupiter or slightly beyond the orbit of Callisto.

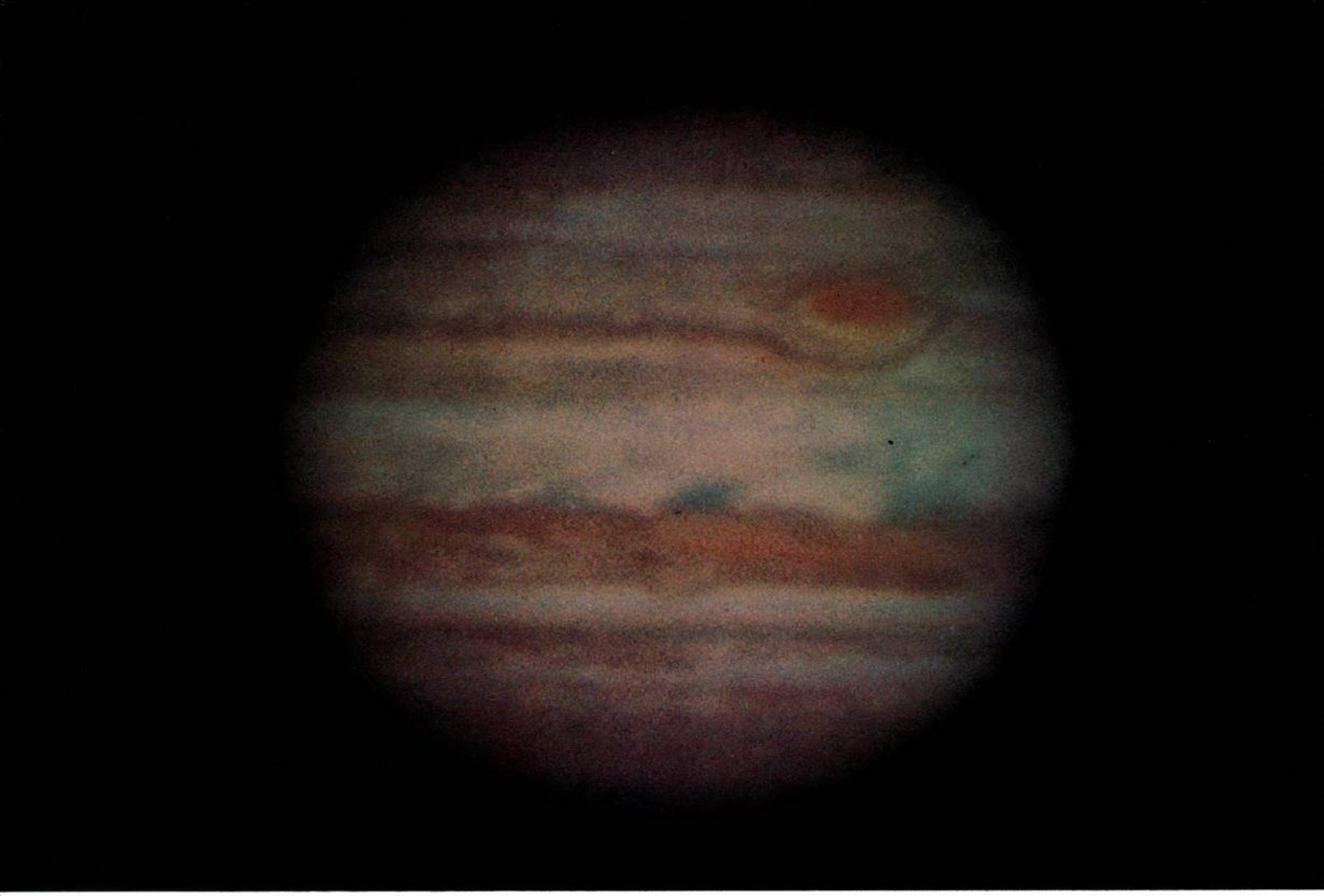
So you can be your own space traveler and place yourself on a moon of Jupiter by simply setting up your telescope, pointing it at that brilliant object in the southeast (the one that's brighter than anything else in the evening sky) and focusing the telescope. The only thing you can't control is the unpredictably turbulent atmosphere here on our planet that can spoil what otherwise would be the view that you would get as a spacesuited, Callisto-roving astronaut.

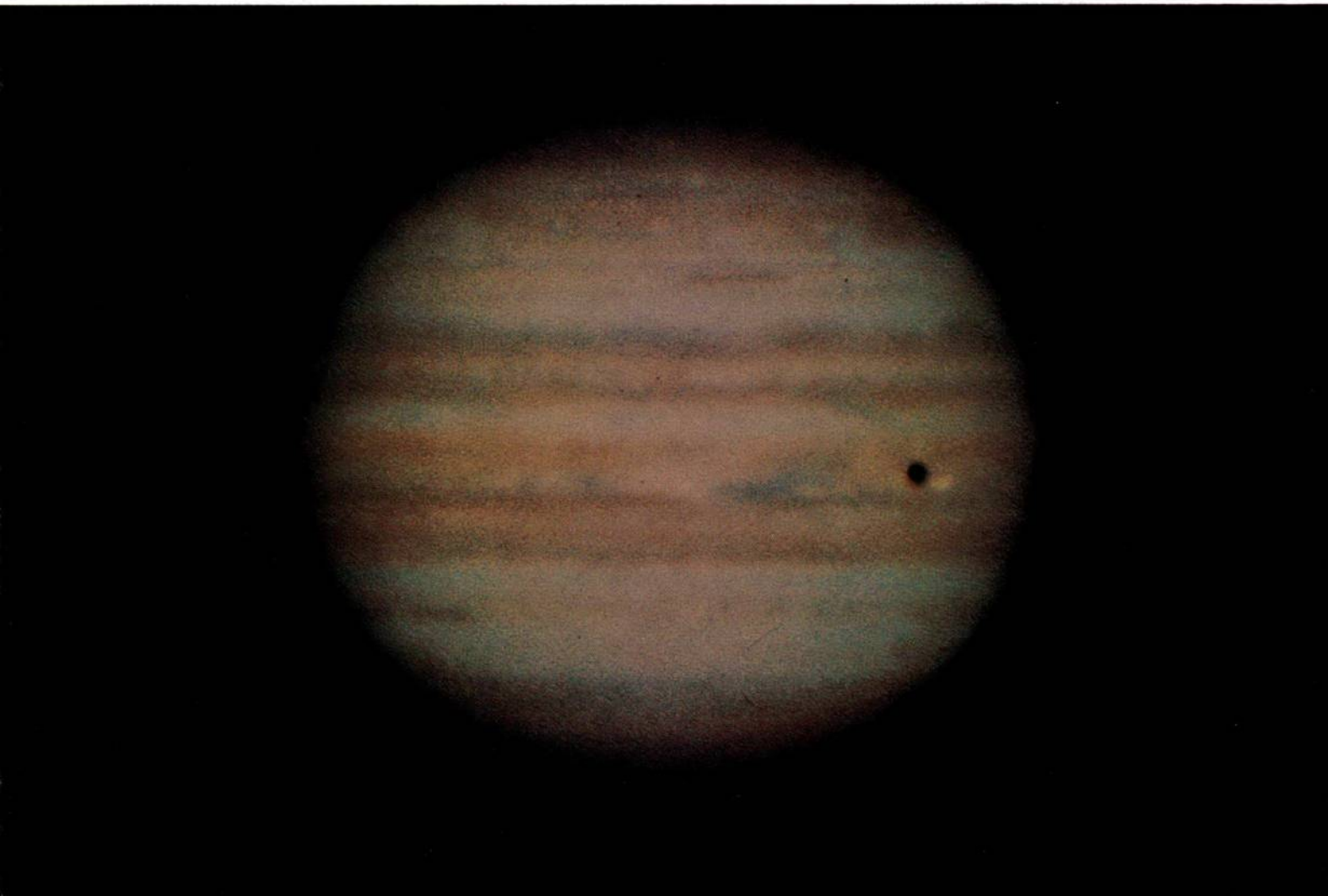
Let's get a little bit more "down to Earth" as far as observing is concerned and find out precisely what we can expect to see in a particular telescope when we train it on Jupiter. Certainly the most fascinating aspect of Jupiter for those who possess smaller telescopes is the antics of the four large moons which orbit Jupiter in periods ranging from just under two days for Io (the nearest of the big four) to about 17 days for Callisto. The dance of the satellites can be followed with any telescope magnifying 20 times or more. A two inch refractor with a 20 or 30 power eyepiece is perfectly adequate to completely follow the zigzag paths of all four of these satellites (each one of which is equal to or larger than Earth's single satellite).

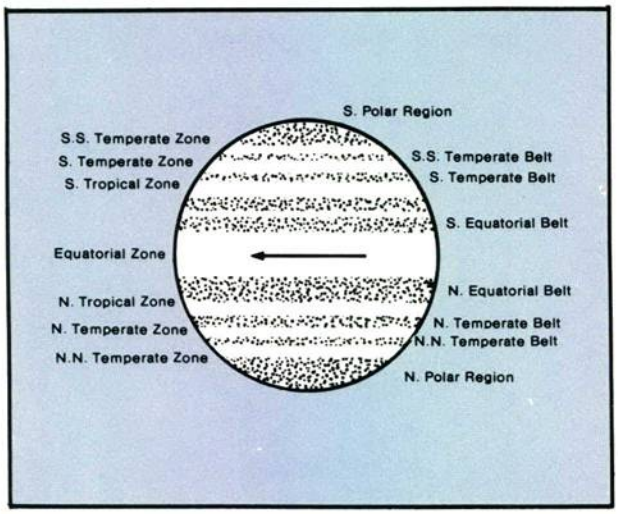
The moons are really a never-ending fascination — sometimes two are on one side of the planet and two on the other; sometimes one is missing, either behind Jupiter or in the planet's shadow. Much more interesting are the frequent

The dark bands and lighter zones of clouds that cloak the colossal globe of Jupiter are constantly shifting. In these two photos an unusually vast change in the planet's complexion is seen. The upper photo, taken in Dec. 1966, reveals a wide festooned equatorial zone while the dark north equatorial belt (horizontal band just below center) is thick and colorful. Only 14 months later (lower photo), the situation is completely different with less turbulence and more distinct, thinner dark belts. The detail displayed in these photos — among the finest ever taken from Earth — can be seen visually by an experienced observer using an eight inch telescope under excellent atmospheric conditions. Gross changes can be noted with much smaller instruments.

Lunar and Planetary Laboratory Photographs







The dark belt and light zones of Jupiter, all semipermanent, have been named to facilitate descriptions of features of interest. The image has been inverted to correspond to the view in an astronomical telescope. All photos and drawings in this article also have south up (S=south; N=north).

occasions when one of the moons is casting its tiny shadow on the disk of the planet. According to some observers, this phenomenon is evident in a good 60mm (2.4 inch) refractor. Using such an instrument at 70 to 100 power, the tiny ink black shadow of one of the moons can be seen especially if it's on one of the brighter zones of Jupiter. The shadows become more evident when a larger telescope is employed.

Because of the different sizes of the satellites and their varying distances from Jupiter, the shadows that they cast are of different sizes. Io and Ganymede produce shadows about 1,700 miles in diameter whereas Europa and Callisto cast significantly smaller shadows approximately 1,000 miles across. Sharp eyed observers have seen the shadows of all four with 60mm refractors — but for general conditions and the average eye (if there is such a thing) the four are usually evident in a four inch or larger telescope.

The times when the shadows are visible on the disk of Jupiter are given in Sky Almanac every month during the time Jupiter is conveniently positioned in the sky. Sky Almanac also has a table showing the approximate positions of Jupiter's moons for each evening of the month. The chart cannot show how some moons seem to pass rather close to one another but this can be observed if you happen to be looking at the right time. Then the motions of the moons become apparent in only a few minutes, especially if they're moving in opposite directions. Experience is a good guide here because as you become accustomed to the appearance of the satellites and watch from night to night you become familiar with which one is going which way. Is it passing behind the planet or sweeping in front of it?

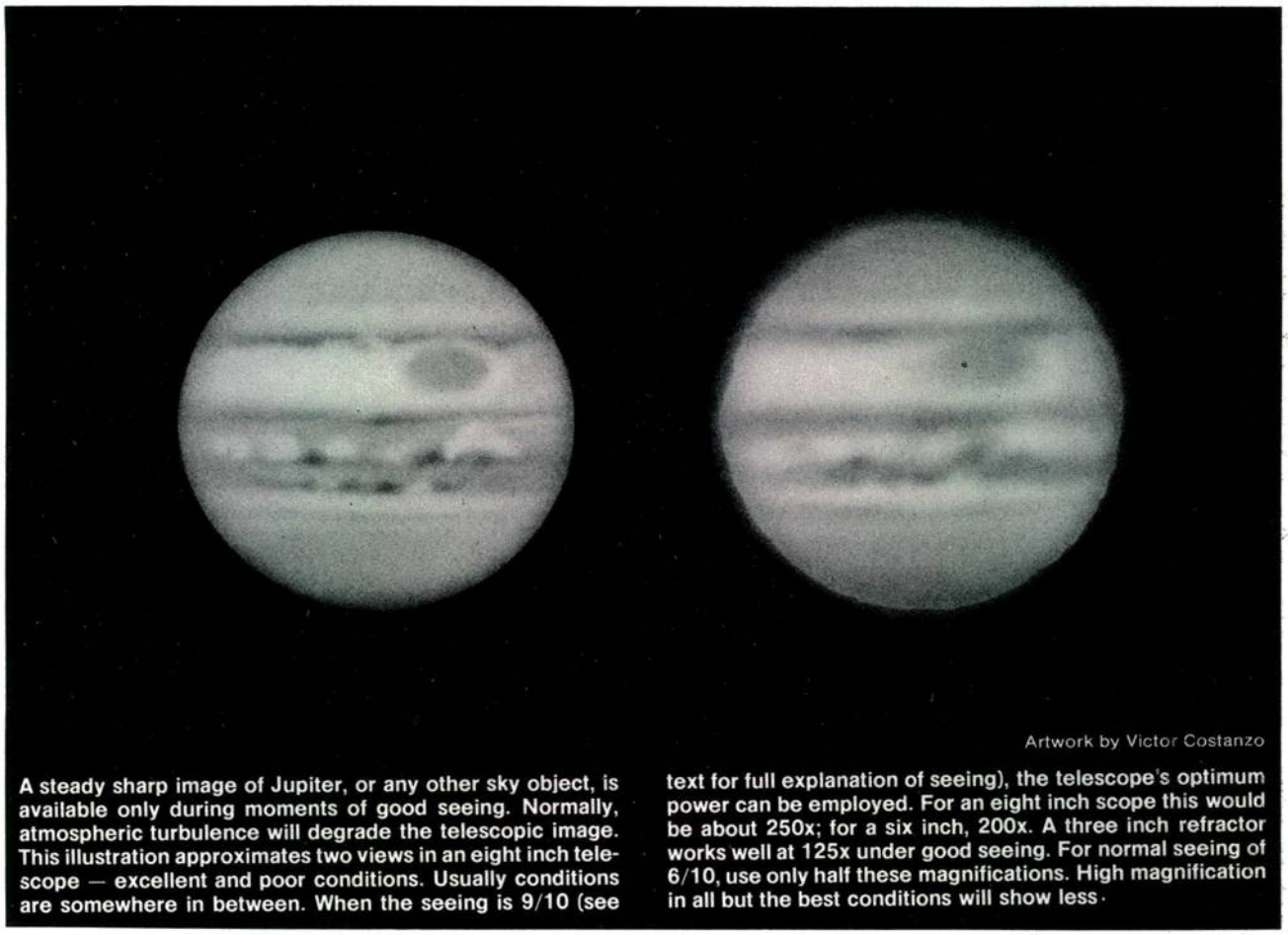
Most telescopes invert the images of sky objects because an extra lens is required to flip things right side up. Astronomical telescopes are designed to have as few light absorbing lenses as possible — hence the inverted image. So everything you see in your Jupiter scene is upside down. Jupiter rotates from right to left with the Red Spot in the top (southern) hemisphere. If you normally use a diagonal on your scope (the right angle eyepiece holder that slips into the focusing tube), then things are further confused with left and right still reversed but north and south are flipped back to normal! If that frustrates you, forget it and enjoy the view until you become familiar enough with your scope to master its image reversals.

One more point about the satellites before we get back to the planet itself. The orbits of the four big moons are nearly exactly in the plane of Jupiter's equator. But since Jupiter stands up almost vertically with its axis tipped only three degrees, the plane of the equator and the orbits of all the satellites are seen nearly edge-on. It's like watching a billiard game with your eyes at table level. The moons swing back and forth without deviating from a thin zone on either side of Jupiter.

The cloudy, wind-swept surface of Jupiter

Photograph by John Sanford

Jupiter's four big moons are always strung along an imaginary zone running through the planet's equator. This photo approximates the view in a small telescope at about 30 power.



Artwork by Victor Costanzo

A steady sharp image of Jupiter, or any other sky object, is available only during moments of good seeing. Normally, atmospheric turbulence will degrade the telescopic image. This illustration approximates two views in an eight inch telescope — excellent and poor conditions. Usually conditions are somewhere in between. When the seeing is 9/10 (see text for full explanation of seeing), the telescope's optimum power can be employed. For an eight inch scope this would be about 250x; for a six inch, 200x. A three inch refractor works well at 125x under good seeing. For normal seeing of 6/10, use only half these magnifications. High magnification in all but the best conditions will show less.

is always changing. The vast dark belts merge with one another or sometimes fade to insignificance. The bright zones — actually smeared bands of ammonia clouds — vary in intensity and frequently get carved up with dark rifts or loops called festoons. It's a fascinating spectacle with the most dramatic action in the equatorial zone.

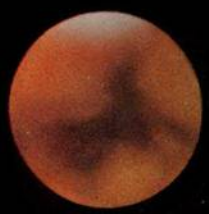
The equatorial region of Jupiter's clouds seems to rotate five minutes faster than the rest of the planet: 9 hours 50 minutes compared to 9 hours 55 minutes. This means constant interaction as one region slips by the other at about 250 m.p.h. Besides the minor disturbances caused by atmospheric current interaction there are major changes that alter the planet's appearance from one year to the next as the two photos on page 45 indicate.

In addition to all the visual goodies described above, 1974 is a particularly good year for Jupiter watching. The planet is well placed in the southern sky this fall — the season with the year's most stable weather conditions — and it is nearly as close to Earth as it can ever get. Minimum possible distance between Earth and Jupiter is 367 million miles. On Sept. 5 the distance between the two worlds is 370 million miles — less than one percent difference. Actually the two planets hover around the 370 million mile mark for the first two weeks of September. The distance slowly increases to 378 million miles by the end of the month. Each month during the prime observing period (September through November) the planet's distance from Earth and apparent size are listed in Sky Almanac.

Jupiter's apparent size is probably the one single factor that makes it so popular with the astronomy enthusiast. Its huge globe, even at its great distance, appears far larger in the telescope than any other planet as the illustration on page 48 vividly portrays. The visible surface area of Jupiter is equal to that of all the other planets combined.

Jupiter's rapid rotation makes the great globe markedly oval so that it appears about seven percent squashed at the poles. (This ratio can be measured directly on the photos on page 45.) In early September the equatorial diameter is 49.5 seconds of arc while the polar diameter is 46.2 seconds. By month's end the two dimensions are 48.4 and 45.2 seconds of arc respectively. These figures are also supplied monthly in Sky Almanac along with other observing data.

Planets: Maximum Apparent Sizes



Mars
25"

Venus
60"

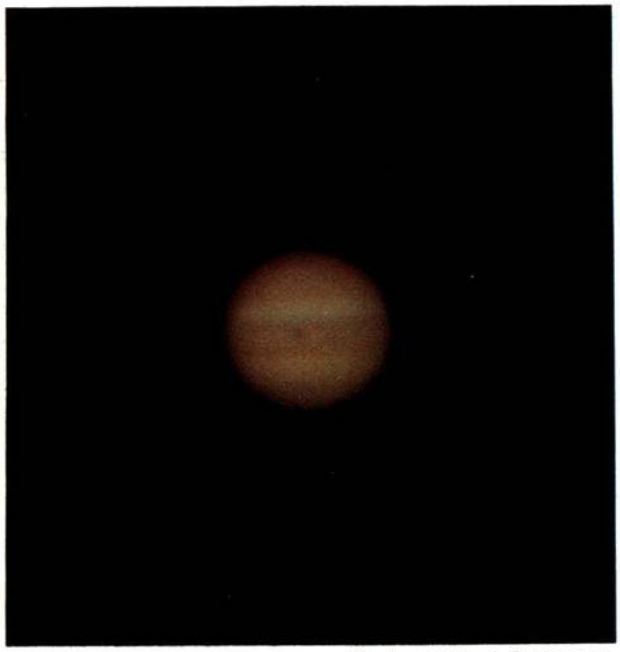
Jupiter
50"

Mercury
11"

Uranus
4.0"

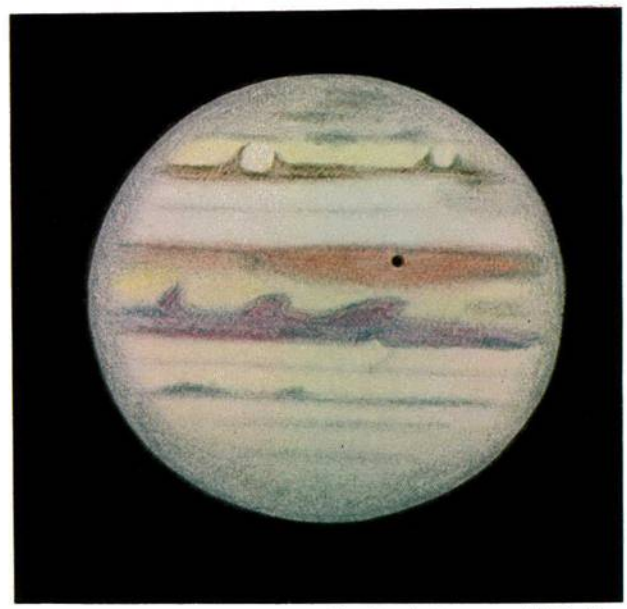
Neptune
2.5"

Saturn
21"
(rings 46" wide)



Photograph by J. S. Hanssen

The shadow of a Jovian satellite is nearly dead center in this photo taken through an eight inch Schmidt-Cassegrain telescope.



Drawing by Lawrence M. Carlino

An experienced planetary observer can see as much detail on Jupiter in an eight inch telescope as can be photographed through the world's largest instruments. The drawing above is an example of such experience combined with artistic skill. It shows Jupiter as it appeared at 1:35 a.m. (EDT) on July 6, 1974. The shadow of Io, Jupiter's inner major satellite, is traversing the south equatorial belt (south is at top as in most astronomical instruments). The satellite itself was just to the left of the disk at this time. The colors and intensities of the surface features are intensified as is customary in planetary cartography. A 10 inch Newtonian reflector was used at 152x; seeing was rated at 6/10 and transparency, 3/5.

So be sure to get a look now while the conditions are good. If you are disappointed with your first look at Jupiter, don't give up. It takes many hours of concentration to train your eye to discern the fine detail that covers the face of the giant planet. However, there will be times when giving up will probably be the best plan. On those nights when the seeing is poor — the planet's image is constantly distorted by atmospheric turbulence — retreat is the only alternative.

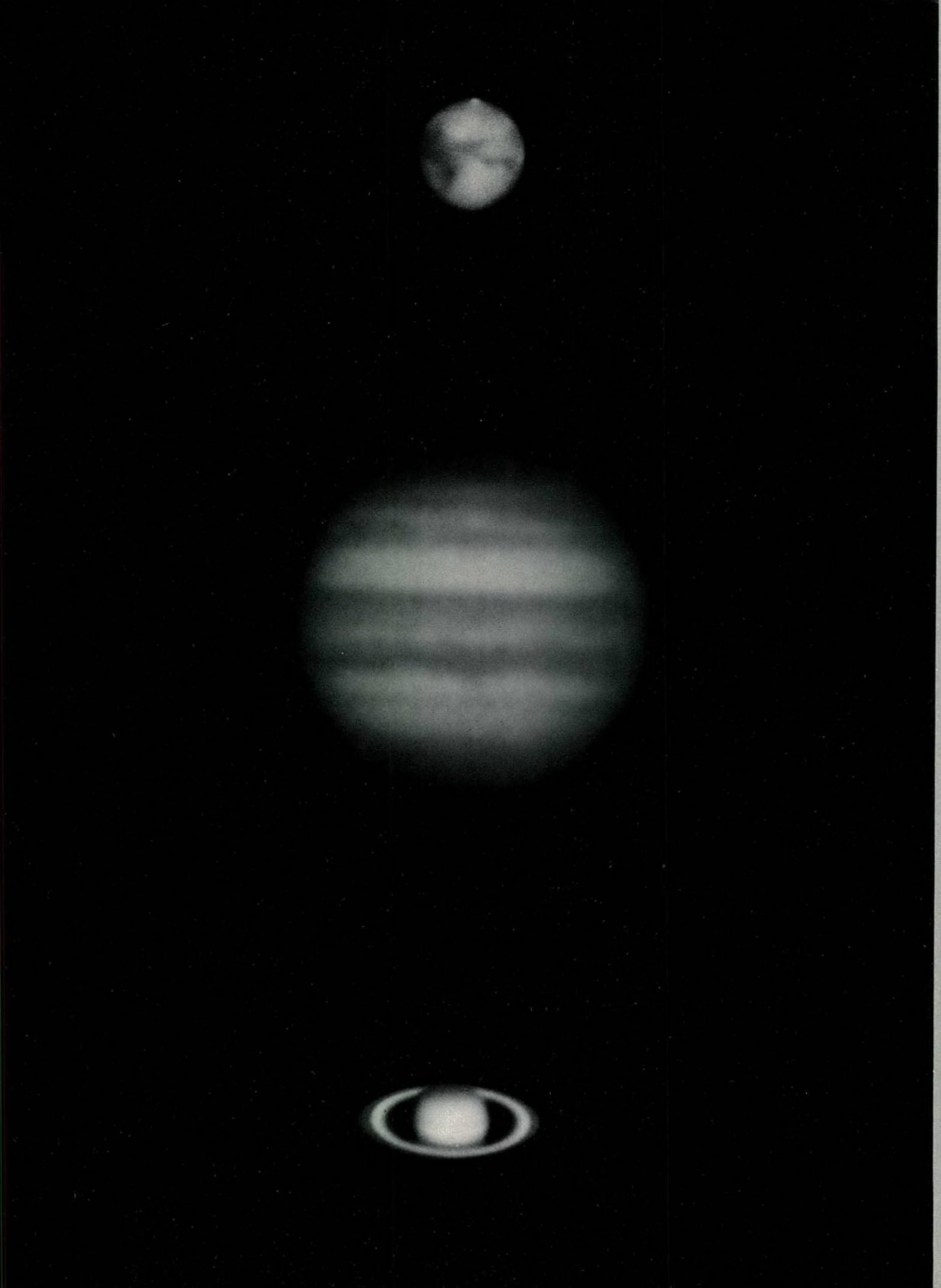
What causes bad seeing? The blame rests almost totally with the ocean of air above us. It's in constant motion and consequently distorts the image you see — something like looking through a fish tank. Distortion usually comes in two varieties: "Fast" distortion is the worst type with constant ripples and fuzziness plaguing the image; "slow" distortion is an in-and-out of focus type of condition where moments of good seeing are mixed in at infrequent intervals. Observers usually rate seeing conditions on a scale of 0 to 10, with 10 being perfect and zero being totally unrecognizable. These two extremes are theoretical and are never used. Fast distortion usually gets a one to four rating depending on how bad it is, while slow distortion can have moments of six or seven on our scale. Perhaps a dozen nights have steady conditions that rate eight, and one or two nights per year (for most locations) will achieve a rating of nine. (Most observers record seeing by using a fraction like 8/10 to indicate they are using the 0 to 10 scale.)

Another useful scale for recording the evening's sky conditions is the transparency rating. This is fairly simple. If you can see sixth magnitude stars (see Star Dome for a discussion of magnitude), rate transparency at five. Drop down one rating with each magnitude until you record a transparency of one if the sky is so hazy that only second magnitude stars are seen.

These two scales — seeing (from 0 to 10) and transparency (1 to 5) are quick and fairly accurate ways of recording how you rated the conditions while observing Jupiter, or any other sky object. But right now try Jupiter — it's there for your exploration no matter what size telescope you have or whether you consider yourself a beginner or a serious enthusiast.

Each planet has its own characteristic appearance when viewed through the astronomy enthusiast's telescope. The amount of detail that can be distinguished depends almost entirely on the planet's apparent size. That's why Jupiter is a favorite target even for small scopes — its visible surface area equals that of all the other planets combined. Although Venus sometimes exceeds Jupiter in apparent diameter, it is only a slender crescent at those times. (The numbers indicate the planet's maximum apparent equatorial diameter in seconds of arc. For comparison, the moon is about 1,800 seconds or 30 minutes of arc in apparent diameter.)

Artwork by Victor Costanzo



Tell the Planets to Say "Cheese"

by
James K. Rouse

Let's suppose it's a beautiful clear September evening. You are examining Jupiter with your eight inch telescope which you think gives a pretty good image. As you watch, more and more detail in the planet's half dozen or so cloud belts comes into view; your eye is becoming more acute as you get used to the image.

Mars, Jupiter and Saturn are captured in remarkable detail through an eight inch f/7 Newtonian reflector. The Mars and Jupiter photos are five second exposures on Kodak High Contrast Copy Film, developed in a 1:17 dilution of H & W Control developer for 10 minutes at 80 degrees. For Saturn, Kodak SO-410 film was exposed for seven seconds and then developed in D-19 for four minutes at 73 degrees. The Jupiter and Saturn photos were taken at f/80; Mars at f/105.

Photographs by James K. Rouse

Finally, after about 15 minutes of concentrated viewing, you get fleeting glimpses of fine swirls and loops of clouds on the edge of the belts, especially in the regions where light and dark areas meet. You are proud of your telescope and trained eye, and thankful for your good luck in being able to enjoy an evening of relatively little atmospheric turbulence.

Your next thought is to rush to the house and get your camera so you can have a permanent record of this splendid view. After some fiddling you succeed in getting a few shots. Days later the bad news comes as you pick up the film from the photo dealer — meaningless blurs and pale fuzz-

Photograph by James K. Rouse

The subtle hues of the ringed planet Saturn are very difficult to capture on color film, especially through an eight inch telescope — the size used for this photo. Exposure was five seconds on High Speed Ektachrome, ASA 160. An equatorial belt on the planet and the major gap in the rings, known as Cassini's division, are both recorded in this outstanding example of amateur astrophotography.

balls. The inspiring views of Jupiter are only a memory. You wish you could ask the planet to say "cheese" once again while you snap the shutter.

As explained in Gazer's Gazette this month, the camera never reveals the detail the eye can see on the planets. However, good planetary photographs are possible with an eight inch telescope as the photos on these pages attest. But it takes patience and experience as well as the very best seeing conditions, good optics and an accurate clock drive. Selection of an optimum photographic image size, critical focus, proper exposure, and proper selection of film and developer are also major factors. Darkroom technique plays a vital role too since choice of the wrong paper grade or exposure at the enlarger can spell the difference between success and failure, even when one has a quality negative to work with. An excellent photograph cannot be hoped for unless all of these requirements are satisfied. Happily, if you have good seeing and a quality instrument the rest are under your control. It is up to you to experiment and find the right combination for each celestial object.

First-rate seeing is the first requirement for satisfactory planetary photography. Unless you can see exquisite detail visually you may as well leave your camera on the closet shelf. Good results cannot be expected unless the seeing is at least 8/10. (For an explanation of the term "seeing", refer to page 49.) There's little point in wasting time duplicating past mediocre results with seeing of only 6/10 or 7/10. Unfortunately in most parts of the United States you can usually expect only a dozen or so nights a year when the seeing is 8/10 or better. To be prepared for these rare nights of good seeing you must know in advance what film, f-ratio, and exposure to use on each planet. This selection can be determined by trial and error on nights of poor or average seeing. Then you're ready for that one rare night of superb seeing.

With the standard focusing screens on most single lens reflex cameras, critical planetary focus is difficult to judge due to the lack of image sharpness at high magnifications. When using a camera with standard focusing screen, focusing on an adjacent star is generally easier than attempting to focus on the planet itself. A clip-on accessory magnifier is also a valuable aid. Some cameras provide the option of interchangeable focusing screens. If you're fortunate enough to own one of these, the special photomicrography screens generally available are nearly ideal for planetary photography. A stable drive is essential, as exposures may range up to 10 seconds. Most of the photos shown here were taken using a homebuilt drive made from Boston Gear components and an Edmund 1/15 r.p.m. motor, for a total cost of $35.

The telescope used for these photos is an eight inch f/7 Newtonian with Coulter optics. The tube is made of aluminum, which helps the telescope

Photograph by James C. Blaize

Jupiter's famous Red Spot has been prominent for several years as the 1971 photo shows. For true color rendition, High Speed Ektachrome is considered second to none although its resolution is inferior to slower films. A 10 inch Cassegrain reflector was used for this four second exposure.

achieve thermal equilibrium quickly. This is important because reflecting telescopes of moderate aperture or more will not perform properly until optics and other components are the same temperature as the surrounding air.

Black and White Photography

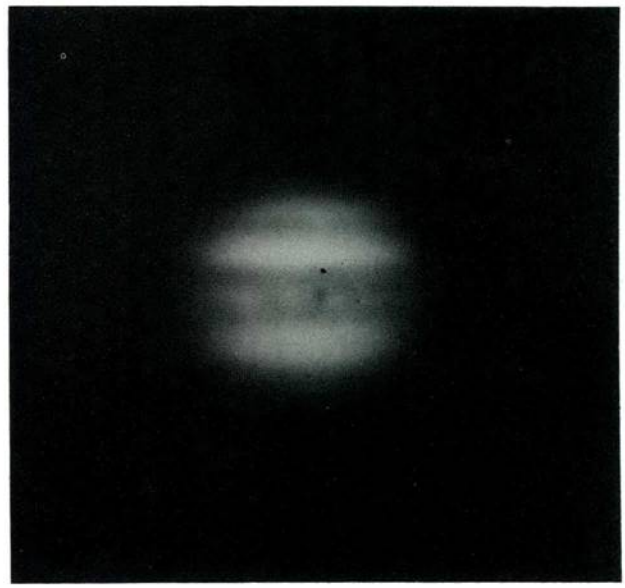
There are many possible combinations of film, developer, image size, and exposure suitable for planetary photography using black and white film — but two are most commonly employed.

1. Fast film, fast developer, large image size, short exposure.

This may be the best choice at times when good seeing comes in "waves" lasting only a few seconds. For example, you could shoot Saturn on Kodak Plus-X film at f/105 with an exposure of one second. Processing in Edwal FG-7 developer will produce an image which is somewhat grainy, but sharp and capable of moderate enlargement.

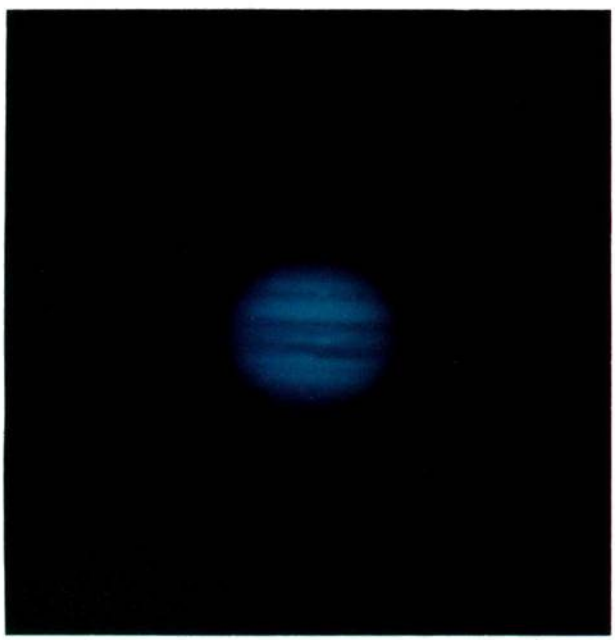
2. Slow speed, high resolution film, fine grain developer, moderate image size, long exposure.

In this case you could use Kodak SO-410 film for Saturn, with a focal ratio of f/80 and an eight second exposure. Processing in H&W Control developer will yield an extremely fine grain negative laden with detail, and capable of 30x enlargement. Naturally you must have excellent seeing, no wind, and a temperature stabilized telescope for such long exposures. You should also be willing to shoot a whole roll or more of film in one outing, using the same predetermined exposure for all 36 frames — because invariably one or two of the exposures will be decidedly superior to the others. This option will probably produce better lunar and planetary photographs.



Photograph by Craig McCaw

A satellite shadow traversed Jupiter's equatorial zone during this view through a 12 inch telescope in July, 1973. Although the shadows are easily seen, the satellites themselves are often the same color as the clouds they are superimposed on, and therefore are difficult to observe and photograph. High Contrast Copy Film was used for this photo.



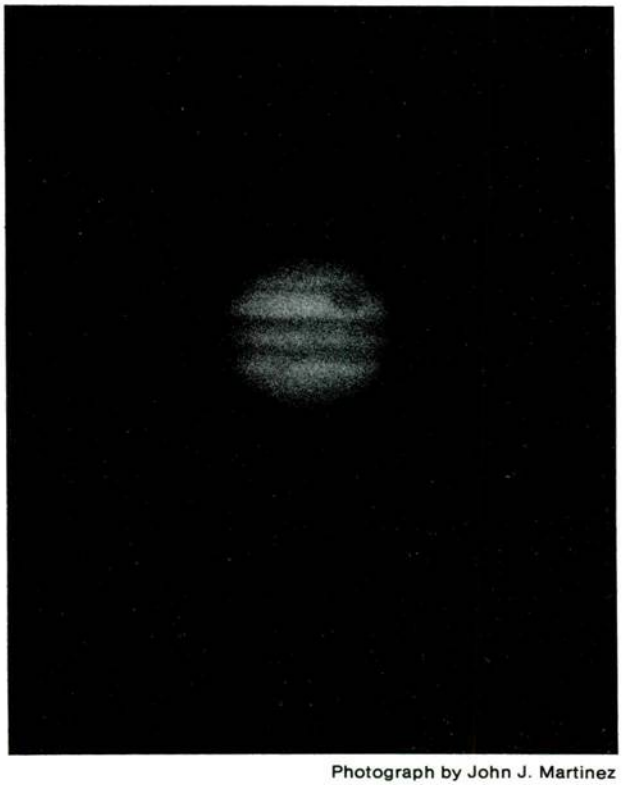
Photograph by James K. Rouse

Jupiter's bold equatorial belts stand out in contrast to the dazzling white zones — a contrast that makes the planet's features easy to observe telescopically and fairly easy to record on film. But the finer detail in this photo is testimony to excellent seeing conditions and great care on the part of the photographer. Another significant factor was the film used: Ektachrome 2483 has high resolution and ultrafine grain characteristics. Its slow speed (ASA 16) required a 10 second exposure, so steady atmospheric conditions were required throughout. This film has a definite bluish cast

For photographing Jupiter and Mars, Kodak High Contrast Copy Film is preferred. It is the highest resolution, finest grained film that is easily available for amateur use. When teamed with the recommended D-19 developer, this film produces exceptionally high contrast; therefore, in order to successfully render gray tones, a developer must be selected which will moderate the film's contrast without sacrificing too much speed. There are several developers available which will accomplish this, including Edwal FG-7, Ethol TEC, Kodak HC-110 and H&W Control developer. My tests rate H&W Control developer as best suited for use on Jupiter and Edwal FG-7 is a close second in terms of the quality of print produced. Exposure for the tests was five seconds at f/80 using a 7mm orthoscopic eyepiece for projection.

In shooting Mars, either H&W Control developer or FG-7 will work equally well with High Contrast Copy Film, since the markings on the

Photograph by James K. Rouse



Photograph by John J. Martinez

An advantage of fine grained emulsion is seen in these two photos of Jupiter. The upper image was taken on Kodak's High Contrast Copy Film while the lower was exposed on Kodak Plus-X. Unless the faster — and consequently grainier — film is used to capture a larger image of the same object, the result is less detailed. Even so, the faster films are often the best choice for average seeing conditions.

red planet are lower in contrast than those on Jupiter. During the 1973 opposition (close approach of Mars) the best exposure was five seconds at f/105, with processing in H&W Control developer.

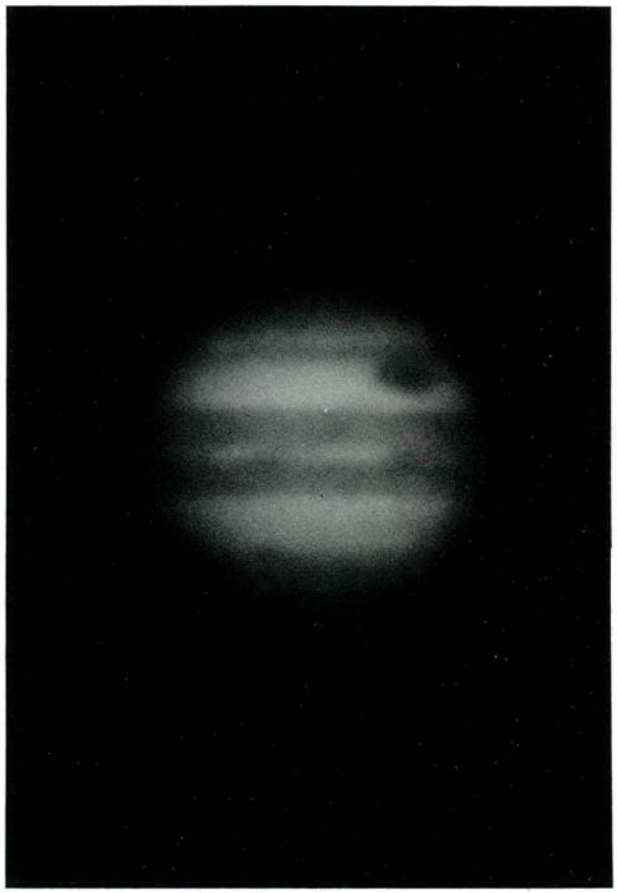
Planetary photographers are usually lunar photographers too. In shooting lunar closeups on High Contrast Copy Film, H&W Control developer again seems the best choice. When the moon is near first or third quarter, a two second exposure at f/40 is about right for proper negative density. When other developers are used, contrast is too high and considerable dodging is required in making a good print. Another combination which works well on closeups of the quarter moon is SO-410 film. At a focal ratio of f/50, a two second exposure is needed with processing in H&W Control developer. Another thing to remember in lunar photography is that the moon's orbital motion carries it eastward its own diameter each hour, so unless you have the means to set your drive to a lunar rate, it will be best to keep exposures down to two seconds or less to avoid blurred images.

SO-410 has nearly the resolution of High Contrast Copy Film and is considerably faster, which makes this film another good choice for Jupiter, Mars and the moon. Keep in mind, though, that you should be striving for the absolute pinnacle of perfection in the amount of detail recorded on film. So when the seeing permits, be sure to use the highest resolution film available.

When photographing Venus, it's often necessary to shoot in a relatively bright sky near sunset or sunrise. Therefore very high contrast is necessary in order to make the planet's image stand out against the bright sky background. In this case, D-19 developer will probably be the best choice with either High Contrast Copy Film or SO-410.

Saturn is a much more difficult photographic object than Jupiter or Mars. It is quite a bit dimmer and has very low contrast cloud belts. Cassini's division seems to defy the astrophotographer's best efforts to render it as sharply as it appears in small telescopes. Most enthusiasts tend to favor the fast film and large image scale approach with Saturn, and many fine photos have been taken using Plus-X, Tri-X and similar films. However with the recent appearance of SO-410, the old standbys are in for some competition. At last we have a superfine grain, high resolution film which has sufficient speed for use on Saturn. Even so, one must be willing to wait patiently for a night of excellent seeing, and use exposures in the six to eight second range at a focal ratio of around f/80.

Another film some of our readers report using with favorable results for high resolution lunar and planetary photography is H & W Con-



Photograph by Leo Henzl

Similar resolution to the High Contrast Copy Film photos of Jupiter on the previous pages was obtained in this view on H & W Control film. The four second exposure was developed 12 minutes in Edwal FG-7, diluted 1:15 at 70 degrees. A 16mm eyepiece projected the Celestron eight inch telescope's image to a ratio of f/80.

trol Film. This emulsion offers a combination of fine grain, reasonable speed and contrast similar to that of Kodak SO-410.

For lunar photography, H & W Control developer is recommended to produce negatives of normal contrast. A development time of 14 minutes at 70 degrees Fahrenheit (diluted 2ml. of this developer per ounce of water) will produce an ASA speed of about 64 and negatives that print well on #3 grade paper. For planetary photography, a 12 minute development time at 70 degrees Fahrenheit in Edwal FG-7 developer, diluted at a ratio of one part developer to 15 parts water, will yield approximately the same speed with somewhat higher contrast.

Now that everything has gone well, and you possess a negative of super quality, what are you going to do with it? The wrong choice of printing paper can spell disaster for a good negative. As every skilled photographer knows, a high contrast negative requires low contrast paper, and vice versa. In astrophotography this is generally true also. A low contrast, three second exposure of Saturn may print well on Agfa Brovira #6, even though the grain stands out like salt and pepper. However a five second exposure would probably print well on #2 paper, and subtle details will be better defined and with less apparent graininess. So for a print of optimum quality, it is generally best to expose a little longer at the telescope so that a normal grade of paper may be used. Selection of the proper paper grade is something that must be done with each individual negative. The experimentation takes time, but it pays off in results. Be prepared to spend at least an hour printing a quality negative.

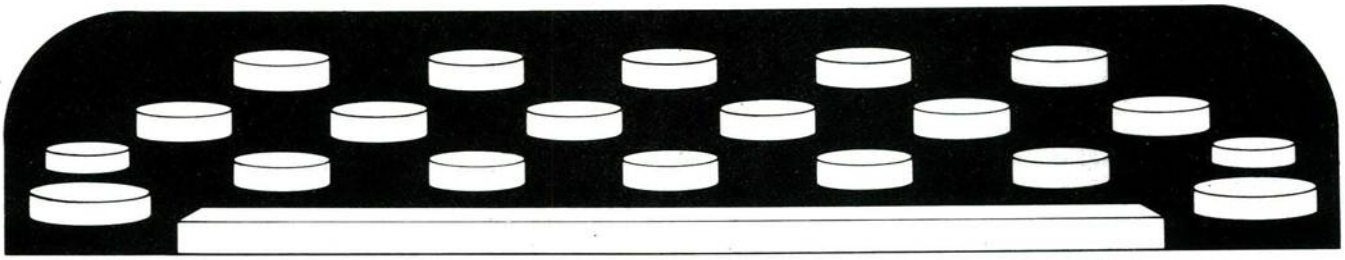
Color Photography

For color work the same principles apply — only fined grained films will yield ultrasharp images. Because of the three sensitized layers in color films, they tend to be less sharp and more grainy than films of comparable speeds. In general, transparency films will yield sharper images than color negative films.

For Jupiter, Mars, Venus and the moon, Kodak's new high resolution Ektachrome 2483 Photomicrography Color Film has extremely fine grain and barely sufficient speed at ASA 16. Kodachrome 64, a new film that has great promise, is now being tested and will be evaluated in a future article. Photographing Saturn in color through moderate size telescopes requires a medium or high speed film. High Speed Ektachrome works quite well, and when processed at its normal speed it produces an essentially true color image of Saturn. Since most photographers leave color processing to the professionals there is much less opportunity to become involved in producing optimum results. The esthetic appeal of color, however, cannot be denied.

Hopefully, the suggestions presented here will be of some value to beginners in planetary photography. The photos accompanying this article represent the best of four years of experimentation with many film and developer combinations. What you don't see are thousands of frames which ended up in the garbage due to poor seeing, misalignment of the telescope, improper selection of film or developer, wind, and countless other gremlins.

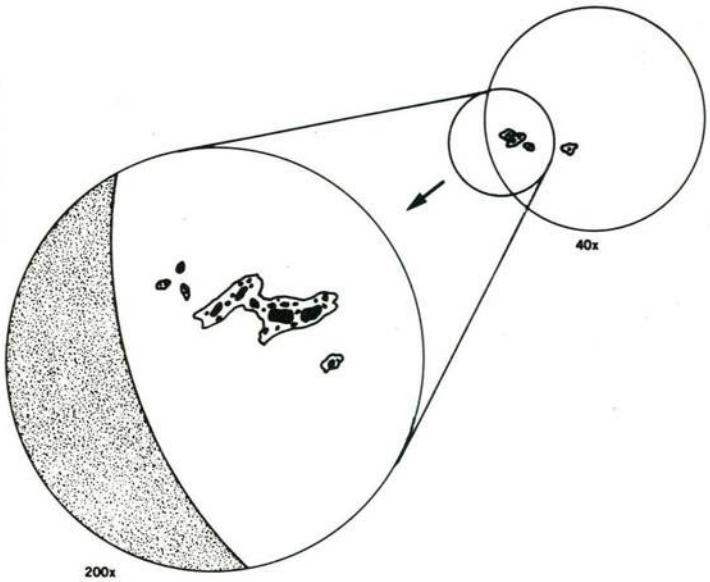
Jim Rouse is a self-employed chemist currently involved in various forms of wastewater analysis. Interest in astronomy blossomed in 1965 while he was enrolled at Florence State College in northwestern Alabama where he had access to a 14 inch telescope. His interest in astrophotography began in 1969, and has become his field of primary interest — especially lunar and planetary photography which he conducts from his home in Naples, Fla.



IN FOCUS

Sir / I thought you might be interested in these drawings of the activity on the sun in July, 1974. I used my 2.4 inch refractor to project the sun's image onto the paper. At 40 power the entire disk was seen — but for detail in the major spot I used 200 power. The drawings were made between 1:30 p.m. and 2:30 p.m. EDT, July 6.

DAVID BUCKLEY
South River, N.J.



Announcing . .

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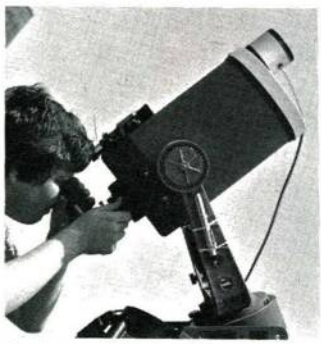
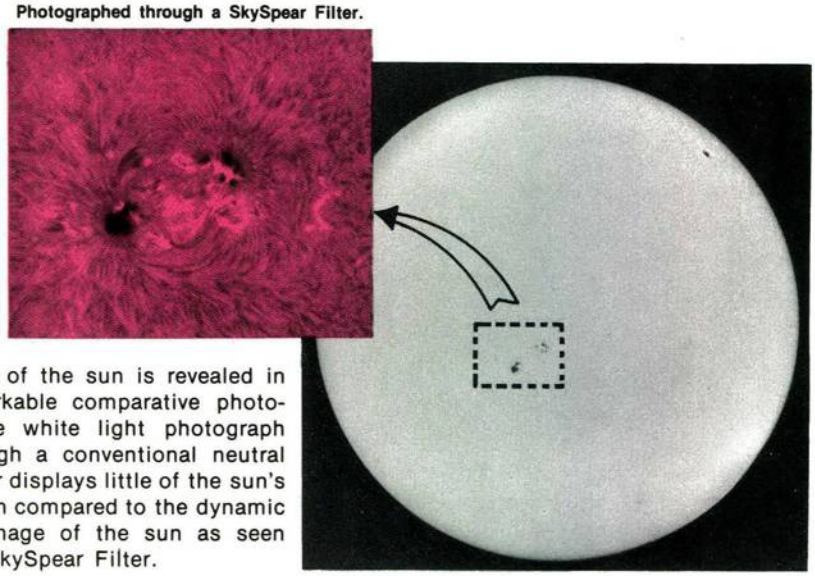


SkySpear Filter mounted on an 8" Celestron telescope.

Photographed through a SkySpear Filter.



The surface of the sun is revealed in these remarkable comparative photographs. The white light photograph taken through a conventional neutral density filter displays little of the sun's activity when compared to the dynamic hydrogen image of the sun as seen through a SkySpear Filter.

Photographed through conventional neutral density filter.

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CONSTELLATION CLOSE-UP

CYGNUS

by
Thomas C. Bretl

Unlike the constellations of spring which plunge so quickly into the long summer twilight, summer constellations seem to linger forever — even as the days begin to shorten once again. In fact, the early evening sky of mid-September appears much the same as it did two months ago. Ever lengthening September nights herald the coming of autumn, but summer stars can still be seen at their very best — and now at a much more convenient hour.

Cygnus the Swan is one summer constellation which certainly deserves this long run upon the celestial stage. It is a striking group of stars, with something to offer everyone. To the naked eye, its brighter members form the famous Northern Cross, while its fainter ones outline the amazingly recognizable wings of a graceful swan; for those equipped with binoculars, it offers dense star fields and coarse, bright clusters; to those observing with a telescope, it reveals tiny planetaries as well as huge, but faint, diffuse nebulae.

The object most often observed in Cygnus, however, is neither a cluster nor a nebula; it is Albireo (Gamma Cygni), the third magnitude star which marks the head of the swan or the bottom end of the cross. Albireo is one of the most colorful double stars in the sky. Its third and fifth magnitude components, easily split with a two inch refractor, are a stunning yellow and blue. Although the contrast between them certainly enhances their colors, even with one component out of the field of view the other retains its own distinctive hue. For first time observers who have never realized that stars have colors, Albireo is sure to provide a beautiful and dramatic surprise.

Another colorful multiple star, and one that is especially suitable for observation with a small telescope, is Omicron-two Cygni. Located about five degrees northwest of Deneb (Alpha Cygni), Omicron-two consists of three widely separated stars of magnitudes 3.7, 5.0 and 6.5. Their colors — orange, white and blue — are in striking contrast, and the entire field is exceptionally impressive. Because of the very wide separations between the three components, very little magnification is either necessary or desirable. Nevertheless, do not neglect this area even if your telescope is quite large — in a 12 inch reflector at 60x, Omicron-two is an extremely beautiful sight! Besides, should you hunger for a more difficult target, you can always search for NGC-6884 which lies 1/2 degree to the west. This 12th magnitude planetary nebula is very small and starlike, and poses a formidable challenge to the most experienced observer. Only its pale blue color and slightly hazy appearance under moderate magnification help to give it away.

Variety is the key word in describing the open clusters in Cygnus. Some of them are large and loosely scattered groups, while others are rich and concentrated; some contain stars with a wide range of magnitudes, while others are much more uniform; some stand out clearly against the background sky, while others almost lose their identity in the rich Milky Way that surrounds them. This means that not all can be seen at their best with the same optical aid. The large bright clusters, for example, require the low power and wide field of binoculars or small telescopes, while those containing many fainter stars demand the light gathering power of larger instruments.

M-39, one of two Messier objects in Cygnus, belongs in the large and bright category. It has a diameter of at least 1/2 degree and contains about two dozen member stars, all between seventh and tenth magnitudes. Look for it with binoculars — it is easy to find just north of Rho Cygni — or use your telescope at lowest power. Only then will it fit comfortably within the field of view and retain its attractive clusterlike appearance.

NGC-7044, on the other hand, is at the other end of the spectrum. This obscure cluster is much

richer and more compressed than M-39 but, unfortunately, is also much fainter and harder to find. This is not because of its meager total magnitude of 11, but rather because of the extreme dimness of its individual stars. Ranging in magnitude from 15 to 18, they are of course impossible to resolve in a small telescope. Through all but very large instruments, the cluster appears only as a faint, hazy cloud about 15 minutes of arc in diameter. To locate NGC-7044, search about two degrees southeast of Xi Cygni; this one is definitely a challenge! Once found, it is hard to believe that this pale spot and M-39 both belong to the same class of objects.

The rest of the open clusters in Cygnus fall somewhere between the extremes of M-39 and NGC-7044. M-29 and NGC-6910, for example, are fairly bright and sparsely populated groups, while NGC-6819 and NGC-7086 contain a great number of fainter stars. Again, variety is the key word! Watch also for some interesting shapes and patterns: NGC-6866 looks much like an arrowhead, while NGC-6811 seems to be starless in a cross shaped pattern that divides it into four parts.

TABLE OF OBJECTS IN CYGNUS

Double Stars

Star	Mag.	Sep.	Colors	R.A.	Dec.
β(Albireo)	3.2 - 5.4	34.6"	Yellow, blue	19^h29^m	+27°55'
16	5.1 - 5.3	38.5"		19^h41^m	+50°28'
δ	3.0 - 6.0	2.1"		19^h44^m	+45°04'
o^2 (32)	3.7 - 5.0 - 6.5	337", 107"	Orange, white and blue	20^h12^m	+46°34'
52	4.3 - 9.6	6.4"	Yellow, blue	20^h44^m	+30°37'
61	5.5 - 6.3	27.0"		21^h05^m	+38°34'

Clusters

NGC	Overall Mag.	Size	R.A.	Dec.
6811	9	15'	19^h37^m	+46°30'
6819	10	6'	19^h41^m	+40°08'
6866	9	6'	20^h03^m	+43°55'
6910	7	8'	20^h22^m	+40°42'
6913 (M-29)	7	12'	20^h23^m	+38°27'
7044	11	4'	21^h12^m	+42°23'
7086	9	8'	21^h30^m	+51°29'
7092 (M-39)	5	30'	21^h31^m	+48°20'

Planetary Nebulae

NGC	Mag.	Size	R.A.	Dec.
6826	9	0.5'	19^h44^m	+50°28'
7008	13	1.3'	21^h00^m	+54°27'
7026	12.5	0.3'	21^h06^m	+47°45'
7027	10.5	0.2'	21^h06^m	+42°08'

Diffuse Nebulae

NGC	Size	R.A.	Dec.
6960, 6992 (Veil nebula)	190' x 8'	20^h44^m 20^h55^m	+30°46' +31°34'
7000 (North American nebula)	100' x 120'	20^h58^m	+44°12'

Epoch 1970

Cygnus's diffuse and planetary nebulae provide contrasts that are even greater than those provided by its open clusters and colorful double stars. Its diffuse nebulae are extremely large and faint, while its planetaries are very small and bright. Thus the former are hard to see at all, and the latter are difficult to distinguish from surrounding stars.

The North American nebula (NGC-7000) is one of the largest of all diffuse nebulae. It covers several square degrees of the sky just west of Xi Cygni (between Xi and Deneb) and its total magnitude must be tremendous. It is so spread out, however, that inch for inch it is extremely faint. As a result, although it photographs beautifully, it is very difficult to observe visually. You can get a good feel for the problem by putting the image of a single star far out of focus — it becomes much harder to see, or even disappears. The North American nebula is, in a sense, always out of focus.

Even the use of a larger telescope does not solve anything. Although a greater aperture produces a welcome increase in light gathering power, the necessary accompanying increase in magnification spreads out the light even more. We're just "spinning our wheels". The North American nebula is equally difficult to see in binoculars or a 6 or 12 inch telescope. There are some tricks, however, that can help you get a glimpse of this famous nebula. Wait for the clearest of nights, when the Milky Way seems especially bright. Let your eyes become well adapted to the dark and use the lowest possible power. Remember that even then the entire nebula is not going to fit within your field of view. Finally, sweep your telescope slowly back and forth and watch for the subtle increases in brightness that mark the edge of the nebulosity. It is worth the trouble; this area is so rich in stars, and contains such mysterious dark and light patches, that it is certainly one of the most beautiful regions of the summer Milky Way.

The other famous diffuse nebula in Cygnus is the Veil, a giant loop of nebulosity that lies near Epsilon Cygni. Two sections of this loop (catalogued as NGC-6960 and NGC-6992) are bright enough to be detected visually, and although neither is much more conspicuous than the North American nebula, both are somewhat easier to find and identify. A fourth magnitude double star, 52 Cygni lies right in the middle of NGC-6960 and makes it the less difficult of the two to locate. Unfortunately, the light from this star also tends to flood the faint nebulosity. If you keep 52 just outside the field of view, however, you should be able to glimpse the nebula's pale ribbon of light on a line running north and south. This section is about one degree long, but only a few minutes of arc in width — its brightest part lying on the northern side of the star.

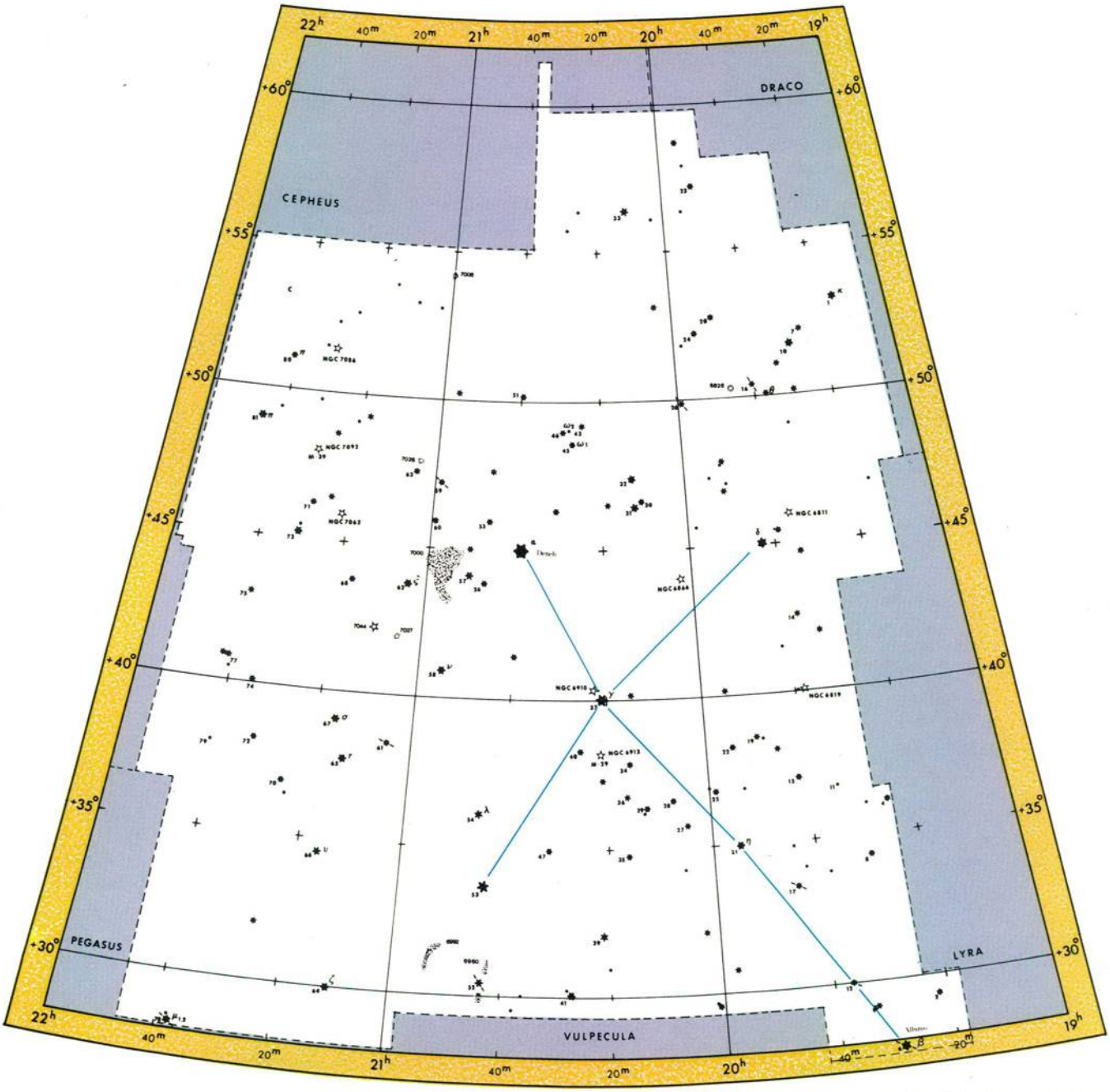
Finding NGC-6992 is more difficult, but also perhaps more exciting. Start at Epsilon Cygni and sweep in a southeasterly direction along a line drawn through Epsilon and Gamma. Soon the large crescent shaped nebula will enter your field of view. It too is about one degree long, but it is somewhat wider than NGC-6960 and brighter near its ends. Under the best seeing conditions, it takes on a rather mottled appearance with definite brighter and darker areas. Usually, however, it is but a ghostly cloud — quick to vanish in the slightest haze or moonlight.

Unlike these diffuse nebula, planetary nebula are often very bright for their size. Some, in fact, are several hundred times as bright as the same size "piece" of the North American nebula. Usually they are also quite small and difficult to pick out in a field of stars, so they lose their advantage in brilliance when magnified enough to reveal any detail. Fortunately, Cygnus contains several exceptions to the rule that are very interesting objects to observe.

In the western wing of the swan, for example, is NGC-6826 — a ninth magnitude planetary that is almost 1/2 minute of arc in diameter (about the apparent size of Jupiter). It is easy to find because it is in the same low power field at 16 Cygni (another double star) and is particularly interesting because of its clearly visible 10th magnitude central star. A pale blue haze surrounds the star.

Details of three other planetaries in Cygnus are described in this month's table. For observers with an eight inch or larger telescope, all are highly recommended. NGC-7008 is particularly interesting because it is large for a planetary and seems to have at least two faint stars lying within it, while NGC-7026 is worth a look because of its curious figure eight structure. Finally, NGC-7027 is the brightest and best known of the three, and despite its small size is easy to find near Xi and Nu Cygni. It, too, has an interesting shape and a definite bluish color.

Once again, space does not permit a full description of all the objects this rich constellation has to offer, just as time will probably prohibit most observers from completely exploring them with their telescopes. T. W. Webb once wrote: "I had at one time projected a survey of the wonders of this region with a sweeping power; but want of leisure, an unsuitable mounting, and the astonishing profusion of magnificence, combined to render a task hopeless for me which, I trust, may be carried through by some future observer." That task still awaits!



Map by Raymond G. Coutchie

With the Milky Way as a backdrop, the constellation Cygnus is spangled with swarms of stars and wisps of nebulosity. With the map as basic identification, the true shape and size of open clusters M-39 and M-29 can be examined in detail in the photograph. NGC-7000, the North American nebula, lives up to its name — but the Veil nebula (NGC-6992) seen on this issue's cover is only barely detectable in this cooled emulsion one hour exposure on High Speed Ektachrome with a 6 inch focal length f/2 lens. Can you see everything in this photo using binoculars? The text of this department is a monthly guide to object-by-object exploration of the constellations.

Photograph by Orien A. Ernest

Stellar Magnitudes

Diffuse Nebula Double Stars Variable Stars

Open Star Clusters Globular Clusters

Galaxies Planetary Nebula

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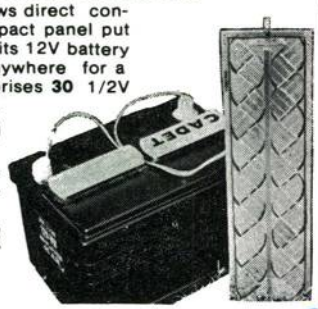

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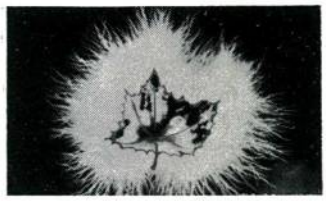

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Notice of Price Change

Effective October 1, 1974 there will be a price adjustment to allow for changing costs. Orders received prior to that date will be billed at the old price (except for those items for which a decrease is announced).

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